Popular Astronomy.

Vol. VIII. No. 9. NOVEMBER 1900. Whole No. 79.

ON LABORATORY METHODS IN TEACHING ASTRONOMY.*

I remember reading once a strangely attractive monograph on "The Hindu Zodiac, or the Discovery of the Lost Key," by N. Chidambarum Iyer, F. T. S., in which he quotes Bhagavan Garga as authority for the statement that "as the night is without a lamp, and the sky without the Sun, so is a prince without an astronomer, and he gropes his way in the dark. That service which an astronomer can render to a prince can not be effected by a thousand elephants and by five thousand horses!"

I strongly suspect that President Hazard, in her historic researches, must already have met this same quaint estimate of an astronomer's worth; for something like a twelvemonth ago she gave utterance, from this platform, to a significant sentiment,—"There have always been women, from the days of the Queen of Sheba, who sought out wisdom and endured arduous toil to come to a fountain head of knowledge." And surely, if the knowledge possessed by astronomers can be worth so much to Hindu princes, *a fortiori* how can the president of an American woman's college afford to do without one? Furthermore, a fine Observatory is no less a fitting corollary of, than a sturdy necessity for, an able astronomer.

But my purpose is other in turning your thoughts thus backward to the very beginnings of astronomy, even to the days of its parentage in astrology, which taught—and in some not very distant cities still affects to teach—the divination of the future by configurations of the heavenly bodies. So deeply rooted was this belief among the early peoples, that kings and potentates were themselves the Astronomers Royal of those days, each devoting himself keenly to the quest of new knowledge concerning the motions of the planets, in the vain hope of truthful prediction of events that might betoken the elevation of his sword or the downfall of his realm.

Virtually everybody believed in astrology; but mankind long

* An address at the inauguration of the Whitin Observatory of Wellesley College, Massachusetts, by Professor David P. Todd, Director of the Observatory of Amhurst College.

since discovered that nothing of the sort obtains. Still, the old beliefs die hard: humanity hesitates to admit that it has been duped. But in this fact, that the astronomy of our own era cannot live up to the pretensions of the past, I see the chief cause for that prevailing lack of interest in the bodies of the sky, which is responsible for an ignorance of astronomy at the present day, dense and well-nigh universal, so far as the masses of humanity are concerned.

I do not say that no one takes an interest in quizzing the telescope man on the Common, and peering eagerly through his "optick tube," if haply he may discover the "man in the moon;" as Piazzi Smyth tells us the inhabitants of Teneriffe, on looking through his telescope, thought they could see their favorite goats grazing on the craggy surface of our satellite.

Nowadays the question most often asked the astronomer in ordinary life—"Are there any inhabitants in the heavenly bodies?" is one that seemingly attracts him least, and is in fact remote from the range of his usual enquiry. And this single question betrays the main trend of unthinking interest of the people in astronomy to-day.

If the astrology of an ancient era fooled the human race, and the astronomy of the present has no answer for this oft reiterated questioning, how can we hope to create that wide and healthful popular interest in the science on which its future development so largely depends?

Clearly, as it seems to me, by a different method of teaching it.

I will not stop to criticise the earlier book-methods: the main criticism is apparent, if I but state the fact that no instructor now teaches geology or chemistry or physics or biology as formerly by books alone: the laboratory is an indispensable prerequisite for instruction in all these sciences.

Why not teach astronomy in like fashion?

Says Professor Huxley in his *Outlines of Physiography*, "The attempt to convey scientific conceptions without the appeal to observation, which can alone give such conceptions firmness and reality, appears to me to be in direct antagonism to the fundamental principles of scientific education." Singularly enough, these self-evident principles have long been neglected in the elementary teaching of astronomy, which is pre-eminently a science of observation, and should be taught as such. Charts of the sky and planispheres have been used in tracing constellations and studying the geography of the heavens, and in a few colleges expensive instruments have been employed by a small body of

students in that training requisite for the professional astronomer.

But we must do much more than this: it is necessary to direct the attention of elementary students to observation of the heavens in that fundamental and practical way which imparts a complete mastery of first principles.

In adopting laboratory methods of teaching astronomy, the degree of attention to manual training now given in the schools is a vast assistance; for instructors and pupils of moderate mechanical deftness can themselves make and use nearly all the apparatus requisite for illustrating these principles, and making observations similar to those that led to their discovery. Only the things commonly found in every house are needed: apparatus is constructed with a little ingenuity, not exact in result, to be sure, but accurate in principle—which imparts the main lesson. And rightness of principle ought everywhere to take precedence of display of mere precision in result, this latter being chiefly the concern of the professional astronomer in perfecting his science.

Will it not enlist the student's interest if we can show him how, with a plumb-line, a paste-board box and a paper quadrant, he can determine for himself the obliquity of the ecliptic within a fraction of a degree?

And abundantly equipped with yardstick, pin-hole and "rule of three," the young pupil may measure for himself the Sun's diameter, arriving nearer the truth than was known in Herschel's time. Youthful students must be taught to connect the principles of astronomy with tangible material objects, somewhat as in physics and chemistry. And although we cannot journey to the heavenly bodies nor touch them, it is clear that a laboratory course in astronomy is practicable, for their light comes to us in decipherable messages, and geometric truth provides the interpretation.

So is it possible to impart a competent knowledge of astronomical principles, and keen interest in their significance, with all that zest characteristic of the geologist, who sometimes affects to know the whole earth—in much the same way, however, as an insect that has bored half way through the shell may be said to know the whole nut. Or of the physicist and chemist who, with all the narrow restrictions of a terrestrial laboratory, are still far from able to tell us all we should like to know about the behavior of matter on an asteroid, or on the Sun, where enforced conditions of temperature and pressure are widely remote from those of our experience here. Or again of the biologist, who has

hardly yet begun to ponder a primal question of the cosmic biology of the future: granted the presence of protoplasm and the chemical elements on Mars, as on the earth, would the process of evolution necessarily develop the same types of animal life on that planet as here?

The truly great astronomer of a coming century must be able to reach a satisfactory solution of such riddles; but to do so he must be equally trained in biology, in physics and in chemistry—quite the opposite direction from that in which present schools are faced. Only thus can we realize that ultimate ideal of our science which was implied by the most eminent of poet-mathematicians, Sir William Rowan Hamilton, who speaks of astronomy as enabling us to "learn the language and interpret the oracles of the universe."

Then, too, we must unceasingly combat the widespread notion that of all the sciences astronomy is the most useless. In reality it is among the most useful; and has always, even in the earliest days of the history of the race, been cultivated mainly for its utility. Consider the question of chronology: many are the disputes over the dates of ancient events that have been settled forever by an appeal to astronomy. Also the important matter of accurate time: the work of the astronomers at Washington affords direct and immediate assistance to hundreds of thousands every day throughout the country, who have engagements to meet and trains to dispatch. One standard clock, when coupled with the telegraph, can effect all this service; but an astronomer must regulate the clock by frequently comparing it with the Sun and stars. Costly instruments are, of course, needed for this work; but the cardinal principles underlying them are quite within easy understanding of young pupils, who should be taught first of all how to find true north from the stars, and then how to construct and use a home-made transit which will give the time, accurate to a few seconds at noon throughout the year. By such methods of teaching astronomy, the Sun by day and the stars by night become part of the apparatus of a grand laboratory, the use of and familiarity with which enhance the pupil's interest with each fresh observation of his own.

In the presence of an audience like this, I do not of course need to emphasize the eminent utility of astronomy in ascertaning the exact boundaries of estates and countries: without an astronomer's help, no nation can make accurate maps of its domain, or trustworthy charts of coast-lines. Nor need I speak of the vast

benefits to all navigation interests, which obtain from the application of astronomical principles in very simple fashion, for conducting ships safely from port to port. Without their astronomical instruments and tables, the good captains who brought us the letters of greeting from Lady Margaret Huggins and Mademoiselle Klumpke, would not have thought of undertaking their Atlantic voyages. And in such measure as the master of a vessel employs the methods of astronomy in guiding his ship across the ocean, by precisely that measure is he an astronomer; because he is an observer of the heavenly bodies, and calculates the observations to find his precise location just as an astronomer would on land, though he usually does this without thinking how many generations of past astronomers have by their observations and mathematical discussions contributed to the perfection of the tables he has used by simple "rule of thumb."

What better training for the keen eye and the steady hand than this same astronomy of navigation? Simple and inexpensive, too, the instruments; and large classes are within easy direction of a single instructor. And as the pupil advances, he may gradually be inducted to practical work with actual astronomical instruments, though of small size; with real telescopes mounted and manipulated in exactly the same manner as the large ones in a fixed observatory.

But I must not pursue these details farther: I have sought only to suggest the lines along which a revolution in astronomical teaching may be brought about. And in so far as the genuine interest of able teachers can be enlisted, the adoption of laboratory methods may be relied upon to create in their pupils a new interest in the things of the sky, both real and abiding.

As America was the first to introduce laboratory methods of instruction in natural philosophy, so too she is the first to set forth the possibilities of teaching astronomy by continual reference to and immediate connection with the laboratory of the heavens. But whether this much desired change in astronomical instruction can be effected in a quarter century, is, I think, very doubtful; for the body of astronomical teachers is, in the main, a very conservative one; and a conservative, as you know, was best depicted by Douglas Jerrold, as "one who would never look at the new moon—and all out of respect and veneration for that ancient institution the old one."

On an occasion like this I cannot, of course, omit remarking the golden opportunity that lies within easy grasp of the well-trained woman, as a teacher of the elements of astronomy by

this new method; and I venture to predict for her that full measure of success in the restoration of astronomy to its ancient seat in human interest, which attended the diligent labors of Caroline Herschel as chief assistant and companion of her brother in his nocturnal watchings, and of Mary Somerville in her essay to popularize the equations of the *Mecanique Celeste.*

In particular must the very young pupil be sought out and instructed to look heavenward. Such teaching cannot, indeed, begin too early; for close upon our childhood's

"Twinkle, twinkle little star,"

follows an alertness of investigation that enables us soon to say,

"Now I know just what you are;
When I see you in the sky,
I the spectroscope apply."

And upon this early interest in astronomy, all the keener and more lasting if connected as in a laboratory with the natural concerns of every-day life, must rest our chief dependence for the future of the science; not only for replenishing that small band of investigators who tread a steady advance beyond the borderland of the known, but for that patronage of the highly intellectual who must provide support for researches in fields, financially non-remunerative, not to say also the costly instruments with which new investigations must be prosecuted.

An American who has made one of the largest gifts to astronomy once told me why he had made that donation: the immediate occasion seemed to be that the president of a youthful and strenuous university had made a powerful appeal. But the prime reason was that this munificent patron had in early life, when studying astronomy at school, become so engrossed therein that he had resolved to build some day the most powerful telescope in the world, if ever he had money enough to do so. The president well knew that he had money enough; but who will say that his appeal would have been successful, except for that unforgotten resolve of an enthusiastic boy?

And from the singularly appropriate edifice that we dedicate to-day, most useful as a complement, and most graceful as an ornament, shall go forth the apostles of this new learning—neither neglecting the old astronomy, nor placing undue stress upon the new; and as they nightly pass beneath its sculptured lintel, ever remembering one whose munificence has inseparably knit her name with that aristocrat of all the sciences, which "contemplated as one grand whole is the most beautiful monument of the human mind, the noblest record of its intelligence."

AN HYPOTHESIS REGARDING THE SURFACE MARKINGS OF JUPITER.

A. E. DOUGLASS.

No planet presents such rapid changes in its surface markings as the largest of them all, Jupiter. The great red belts which are visible in the smallest telescope are constantly changing in minute detail. This is apparently because the belts are on the dividing line between the temperate zone currents and a swifter moving equatorial stream of perhaps twenty thousand miles in width and a velocity of two hundred and fifty miles an hour greater than the regions on each side of it. The markings where these two currents adjoin are literally torn to shreds as Mr. Stanley Williams describes them (Pub. A. S. P., Vol. XI, No. 70). Seemingly the only immovable object is the great red spot and that is not absolutely stationary, for its period of rotation has changed since its first discovery. What then produces this swift equatorial current that rends apart and joins in new forms the red and gray patches along its border?

The polar compression of Jupiter is in the neighborhood of one-sixteenth; that is the polar regions are about six per cent nearer the center of internal heat than the equator. Now owing to the very great reflecting power of Jupiter's atmosphere (albedo 0.62) and its distance from the Sun (mean distance 5.2 or 483,000,000 miles), it is the internal heat that governs the circulation of the atmosphere rather than solar energy and we have an atmospheric circulation the reverse of ours.

Permit the digression in saying that that appears to be the meteorological distinction between a cloudy and a non-cloudy planet. The former controls its own atmospheric movements, producing a convectional current over its hottest parts; the latter has its atmospheric movements controlled by the Sun, with upward currents near the equator. This has a bearing on the rate of cooling of planets.

Upon Jupiter, therefore, the ascent of air occurs at the poles. The masses of warmed air or gases then spread toward the equator. But as their linear velocity about the axis of rotation is not so great as that of the regions nearer the equator, they act as a retarding surface current. On this hypothesis therefore it is the equatorial current that represents nearly the true rotation of the planet, and the temperate zone currents that show us

the retarding action of this planetary circulation, namely two hundred and fifty miles an hour.

Let us in imagination follow the course taken by a mass of air or gas or cloud in this retarding current. In mid northern latitudes the low-level winds far below the visible surface move toward the north pole. Somewhere beyond latitude 60° or 70°, perhaps, a mass gets sufficiently warmed to rise. It does so. Then it commences to move southward toward the equator, but immediately it turns toward the right as its velocity in its new latitudes is not great enough for it to keep pace with the planetary surface beneath it, therefore almost at once begins to retard the velocity at the apparent surface. Its maximum turning force occurs at the start. The latitude of its maximum retardation depends upon the actual rate at which it turns in direction. Now, on the earth, the trade winds are supposed to be composed of masses of air that have actually turned about and are on their way back to the equator. This suggests that on Jupiter the return currents to the pole are down too deep in the atmosphere for us to see them and that the masses that do not turn back are the ones that finally get near the equator. So just as we have on the earth a polar whirl blowing in advance of the actual rotational velocity, so on Jupiter we find an equatorial, or as it happens, a sub-tropical retarding current, opposing the rotational motion.

If these north and south retarding currents actually met at the equator, we would practically be unaware of their existence, for we would have nothing to compare them with and they would hardly show sensible change in rate for many degrees on each side of the equator. But we find an equatorial zone largely unaffected by this retardation, although subject to rapid changes in configuration of detail. There may be at least two causes for the existance of this equatorial zone unaffected by retardation. First, the equatorial retarding currents may be simply not strong enough to reach the equator, for they have turned to an east-and-west direction and have little force left to push on north or south. Second, the effect of heat received from the Sun, even though very weak, would be to expand the air over the equator and cause it to spread north and south, thus interfering with the approach of the retarding currents to the equator, and also causing the slight seasonal change that has been suspected.

Above the actual visible surface that reflects solar light there must be considerable atmosphere for the limb of Jupiter is very dark all around. But as the polar and equatorial zones are also

much darker than the temperate regions, except in small spots, we infer that the gases freshly brought to the surface in the regions of convection have less reflecting power than those in other parts of the planet. The red marks of all kinds act like some kind of cloud condensation, light because they float high in the atmosphere, yet differing from the other visible materials, and showing a strong tendency to accumulate and last longest in the region that upon the hypothesis given above, must be the coldest part of the planet's visible surface.

Perhaps it is presumption to suggest more definitely the nature of the red spot. But the spot can be attributed to some special uprush of the same gas that forms the red belts, but to an uprush which occurred within the colder borders of the retarding current. A strong condensation ensued in the upper levels of the retarding current, followed by a gradual dissolving or falling downward of the red material. As the under side of the red mass is nearer the warm surface of the planet than the upper side, the most rapid breaking up of the mass would, we can infer, occur on the under side. We can therefore conclude that with the breaking up of the red spot and its becoming more and more confined to the upper levels only, of the retarding current, we are getting more and more accurate measures of the surface velocity of the retarding current. As the rotational velocity of the red spot has been decreasing since 1878, we conclude that the surface of the retarding current is moving more rapidly than the lower levels; and that is precisely the effect that friction produces.

At the present time, therefore, the red spot appears to be floating quietly in the retarding current, possibly held in place by an eddy, very slowly breaking up, perhaps already partly covered by other cloudy material and yet still dense and strong enough to preserve its form and size.

LOWELL OBSERVATORY, Flagstaff, Arizona, Oct. 16, 1900.

NOTE—At the Geodetic Congress which met at Paris at the end of last month, Sir David Gill, director of the Cape Town Observatory, reported the progress made in measuring an arc of meridian of 104 degrees from the Cape to Alexandria. They were passing by permission through German East Africa. Five degrees had been already measured in Rhodesia and three and a half in Natal. The measurement by international co-operation of an arc from French Congo to German East Africa was considerrd. A report was also made to the effect that the measurement of the geodetic line between Malta and Sicily had been successfully carried out under the superintendence of Dr. Guarducci, the chief of the geodetic division of the Italian Geographical Institute. The Malta station was at Gozo, and the chief Sicilian stations were on the mountains of Etna and Cammarata. The distance between Malta and Sicily is about 125 miles, and signals were exchanged at this distance by means of the oxyacetylene search-light.—*Science, October 19, 1900.*

JAMES EDWARD KEELER.

BY J. A. BRASHEAR.

"God did anoint thee with odorous oil,
To wrestle, not to reign, and He assigns
All thy tears over like pure crystallines
For younger fellow-workers of the soil
To wear for amulets. So others shall
Take patience, labor, to their heart and hand
From thy hand, thy heart and thy brave cheer."

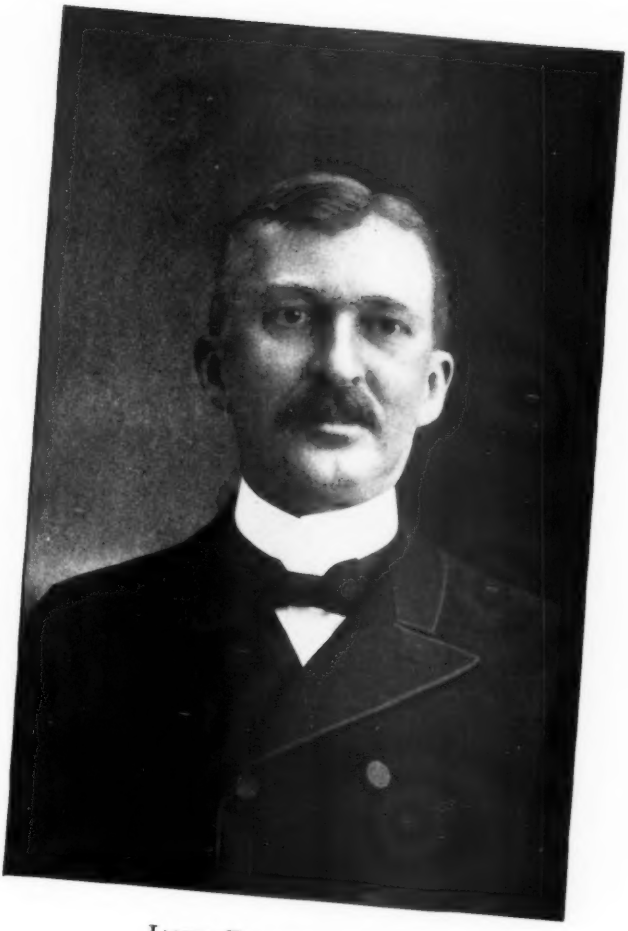
—ELIZABETH BARRETT BROWNING.

A great soul has gone from us, "our" dear Keeler has finished his work among the stars. There is universal sorrow at his taking away; his colleagues on the mountain, his friends everywhere, say, how can it be that so great and promising a life has been blotted out and we left to mourn his loss. A colleague upon the mountain writes: "We are inexpressibly sad, are inconsolable, every one of the fifty people regarded Mr. Keeler as his personal friend! You most assuredly can say that he was liked by all his associates. There was never any unpleasantness in those two years. He made a great success of his own work, and saw that every body else had all the opportunities in the world to do the same. He never questioned or interfered with our plans, with the result that we all kept him posted as to the state of our work. Socially, he and his family were simply delightful. You may say that he established ideal conditions in this ideal place."

One who knew him only to love him writes: "My heart is heavy for Keeler, our dear friend Keeler, the bright, lovable, genial Keeler, who died last night. All day I have been like one in a dream; Keeler, our Keeler, gone." A colleague at the University writes: "All the professors at the University have words of kindness for him, and the deepest sympathy for Mrs. Keeler and the dear children." Another life-long friend writes: "Yes, our Keeler has passed away, well may you and I and Professor Brown call him our Keeler, and all who knew him could call him the same for all his energies and all his marvellous fund of information was ever at the disposal of his friends. I have never met a man in all my life who was more willing and anxious to assist others in every way than he, and how my heart goes out for his dear companion and the children."

Were I to write only of the kindly words that I have received in letters from friends who have known this great man, it would

PLATE XX.



JAMES EDWARD KEELER.

POPULAR ASTRONOMY No. 79. 1857–1900.

fill many pages of this journal. Never have I known such spontaneous expressions of sorrow over the death of a humble student of science, for he was without the least taint of egotism to mar his splendid record.

I have known Professor Keeler for more than twenty years, our first acquaintance dating from the time he came to the Allegheny Observatory to assist Professor Langley in his Mount Whitney expedition. Professor Langley at once recognized his ability, not only with reference to his scientific attainments, but for his knowledge of experimental methods and his mechanical skill. I can remember as it were only yesterday, how I admired his beautiful tool box, made by his own hands, and the fine tools he brought with him from college. Professor Langley at once placed unlimited confidence in him, and many of the more important arrangements of the expedition were placed in his hands. It was during the preparation for the Mount Whitney expedition that he visited our workshop so frequently, and here was formed a friendship that has never been sullied by an unkind word or caustic criticism; a fellowship that has been prolific with pleasureable memories—memories that make life worth living.

I can well remember a remark made by Professor Langley after the Mount Whitney expedition. I was always a welcome guest at the Observatory and it was meat and drink to me to hear of the work done by the Director and his corps of assistants. Speaking of Keeler he said: "I have never known a young man so thoroughly competent as an assistant in scientific research, some day he will make himself known."

William Thaw, that great and good friend of science, who did so much to enable Professor Langley to carry on his researches, saw in Mr. Keeler a "world of promise," and he, with Professor Langley advised him to study a year or so abroad. In 1883 while studying with Helmholtz, he made a thorough study of the selective absorption of radiant heat by carbon dioxide, which was published in the *American Journal* for September 1884. This research at once showed his ability as an original investigator. Although he had been working in the same scientific lines with Professor Langley, as well as in other fields of research, as an assistant, this paper was recognized at once as having an important bearing upon a subject at that time of great interest to the scientific world.

Returning to Allegheny Mr. Keeler assisted Professor Langley in his now historic studies of the infra red end of the solar spectrum and the selective absorption of solar energy.

In one of his papers upon this subject Professor Langley says: "I have received constant and valuable aid from Mr. Keeler, not only in the graphical constructions but in the experiments and in the computations, through all the details of which his aid has been more that of a coadjutor than an assistant." The astronomical world knows the results of the splendid work done by Professor Langley with the assistance of Mr. Keeler and Mr. Very in the early eighties, a work that brought rays of bright sunlight to shine upon the New Astronomy. During these years of hard work at the Observatory, Mr. Keeler made many friends for he was socially a man who was always welcome at the fireside of any household. He could draw from his storehouse of scientific knowledge, weave the facts into fairy stories we all loved to listen to. It was a sad day when he left us for Mount Hamilton.

Professor Holden had asked Mr. Keeler to accept a position upon the Lick Observatory staff, which he accepted. He commenced his work in April, 1886 as assistant to the Lick Trustees, which position he held for about two years. His first task was to establish the time service, which he did most successfully, and and on the first of January 1887 the first time signals were sent out from Mount Hamilton. During the latter part of this period he devoted much of his time to installing the instruments of the Observatory. A very dear friend who spent many months with him on the mountain erecting the great refractor, has often repeated the story of his stay there, in which a friendship of the most endearing nature was formed for the man whose genius and whose kindly nature were such potent factors in the completion of the great Mountain Observatory.

From June 1st, 1888 to June 1st, 1891 he held the position of astronomer in the Observatory. During this time he made his splendid drawings of the major planets, by the aid of the great refractor, and successfully carried out the eclipse expedition of January 1st, 1889, of which he was placed in charge. It was during this peroiod that a life long friendship was formed between those splendid men: Captain Floyd, Burnham, Barnard, Keeler, Schaeberle and Hill. The world knows of their successes in the field of astronomical research. The ranks are broken now for the second time. Among his earlier friends whom he esteemed most highly were Mr. Chas. Rockwell and Dr. Chas. Hastings.

"Great souls by instinct to each other turn
Demand alliance and in friendship burn."

The plans were now made for the first great spectroscope to be constructed for a study of the motion of nebulæ in the line of sight, and which was completed about a year later.

His first measures of the nebulæ with this instrument (as kindly given me by Professor Campbell) are:

Orion Nebulæ, February 13th, 1890.
G. C., June 13th, 1890.

This work alone was of a character that at once stamped Mr. Keeler as an investigator of the highest type, and his subsequent researches in this prolific field have borne out the most sanguine anticipations engendered by his early studies of the motion of the nebulæ.

In 1890 Professor Langley was called to the Smithsonian Institution and the following spring Professor Keeler was unanimously elected to the Directorship of the Allegheny Observatory. Shortly after accepting the position he was married to Miss Cora Matthews, a niece of Captain Floyd, President of the Lick Trustees. Professor and Mrs. Keeler received a most hearty welcome from the friends of the Allegheny Observatory, and he at once commenced his work at the Observatory, which at that time was unfortunately quite poorly equipped for the continuation of the research he had been carrying on at Lick Observatory. William Thaw, the friend and patron of the Observatory had gone from among us, but Mrs. Thaw at once proposed to furnish the means for the construction of a spectroscope and spectrograph of his own design, which, when completed placed Mr. Keeler in the possession of an instrument particularly adapted to his wants, and which proved to be a type thoroughly satisfactory in every way. Mr. William Thaw, Jr., contributed a fund to rejuvenate the mounting of the old 13-inch equatorial and furnish a new driving clock, and the Junta Club of Pittsburg furnished the money to replace the old shutter of the dome, and with these improvements and additions Mr. Keeler commenced a series of investigations, which have been almost epoch making in the history of astrophysics.

Perhaps his spectroscopic study of the rings of Saturn will always be considered his greatest achievement at the Allegheny Observatory, but he was an indefatigable worker, and during his directorate many researches were successfully carried out and during the seven years he was with us, he published forty-eight papers on his scientific investigations, many of them of great value. Besides these his series of articles on the spectroscope have proven to be of inestimable value to young men taking up

this field as their chosen persuit, as well, indeed, to many of the older observers in astronomical spectroscopy.

The limitations of this article prevent my giving even a synopsis of his more important papers, but readers of astronomical and astrophysical literature during the past ten years well know how this literature has been enriched by articles from his master mind.

It has been thought that our dear friend may have been broken down by over work. This I cannot think is true for although he was a most earnest and enthusiastic investigator, I have never seen a man who went about his task with so much ease, so much confidence, so much freedom from nervous haste. Aye, it was a pleasure to see him preparing his spectroscope for a night's work. Always cheerful, happy if results were commensurate with his anticipations, optimistic if otherwise. I cannot but think that this characteristic of the man was a prime factor in his splendid successes. Besides this he was ever ready to help his fellow workers to solve problems that troubled them, and ever willing to give them all the credit of the solution.

In the early part of 1898 an effort was made to raise funds for a new Observatory, and although a large part of the money needed was subscribed by the friends of the institution, the breaking out of the Spanish-American war and other unfortunate circumstances prevented, for the time, a successful issue of this undertaking. About this time Mr. Keeler was offered a position on the staff of the Yerkes Observatory, and he was also elected Director of the Lick Observatory. After careful consideration he concluded to accept the call to the Lick Observatory, and while we were all proud that his genuine worth had been recognized by the Trustees of the University of California, we knew we were to suffer an almost irreparable loss in our own Observatory, but we could not say, stay with us, for here was the opportunity of a lifetime, and it would have been almost sacrilege to urge him to stay under the circumstances.

The words of one of his associates quoted in the beginning of this article tells us the story of the last two years of the life of Professor Keeler. With his kindly spirit he poured oil upon the troubled waters; made every man, woman and child upon the mountain his friend; organized the work and as Professor Hale has said, gave himself the most difficult task of all. After a year of unremitting labor with the Crossly Reflector, he has given to the world the most magnificent photographs of the nebulæ ever produced. Here is the way he modestly gives the results of his

labors. In a letter to the writer dated October 16, 1899, he says: "After spending no end of time on the old mounting of the Reflector I have it working very well indeed and the results of our photographic work are really surprising. I have just sent an article to the *Nachrichten* which describes what is, I think, the best discovery I have made yet, namely, that the majority of the nebulæ are spirals, and that the spiral form is that which is usually or normally assumed by nebulæ in the process of condensation. I have estimated that there are not less than 120,000 nebulæ in the sky within the range of the Crossley Reflector."

Since that letter was written his monographs on the subject have been published in the *Astrophysical Journal*, clearly and cleanly written as is characteristic of all his papers, for Keeler wielded a facile pen; his logic always clean cut and his descriptions wonderfully clear and charming. His lecture courses in the Carnegie Institute in Pittsburg were listened to with profound interest and his generous proposal to open the Allegheny Observatory one night a week, between May and December,—which he faithfully carried out until he left the Observatory—served to create an interest in astronomy among our people which made itself manifest in a most potent way when the proposal to erect a new Observatory was carried out.

But I have, perhaps, already exceeded the limits given me in this sketch of the life work of our departed friend, yet the half has not been told of him who

> "Surveyed God's beauteous firmament unrolled
> Like to a book new writ in golden words
> And turned the azure scroll with reverent hand
> And read to man the wonders God hath wrought."

Professor Keeler's father passed away many years ago, but his good mother, a most noble woman, is still living in Washington, making her home with Dr. David T. Day, Chief of the Department of Mineralogy, U. S. Geological Survey, who married her daughter, the only sister of Professor Keeler. To Professor and Mrs. Keeler were given two bright and lovable children,—Cora and Henry. How great our loss; how inconceivably greater theirs. Our sympathy, aye, that of many kindred hearts goes out to them in their great sorrow.

The scientific world honored our departed friend in many ways, but honors lay lightly upon his great soul, and those who knew him best, knew he would rather see his colleagues gain the coveted prize than to win it himself.

> "Death makes no conquest of this conqueror;
> For now he lives in Fame, though not in life."

THE WHITIN OBSERVATORY OF WELLESLEY COLLEGE.

S. F. WHITING.

The opening of a new Observatory, whether it be primarily for research or primarily for teaching, or primarily to obtain the data for the practical work of the navigator or geodetic engineer is always a matter of importance in the astronomical world. In astronomy, as in every other science, the three classes of workshops and workers are always needed; the investigator and his research Observatory, the teacher and his students' Observatory, the government staff and their naval and geodetic stations. All contribute to the advancement of science, and notably, the teaching Observatory must do something of the work of each to accomplish the best results.

An Observatory, primarily for students' laboratory work in astronomy, has just been opened at Wellesley College, built and equipped by the enlightened liberality of one of the Trustees, Mrs. John C. Whitin.

In the building, the problem of harmonizing beauty of proportion and ornament with adaptation to special functions, has been happily worked out by the architect and director together, and equipment has not been sacrificed to costly material. The plan is that of a dome twenty-three feet in diameter, flanked by wings to the east and west. The smaller one, west, is the transit room, the larger one, east, contains spectroscope and photographic rooms, library and vestibule. A well finished basement affords place for a workshop.

The material is white marble from Georgia quaries with granite base course, and ribbed copper roof, adorned with acroteria with honeysuckle ornament. A brick paved terrace with marble walls leads up to the hooded entrance, above which is carved the seal of the college enclosed in a wreath, bearing the dates 1875, the founding of the college, and 1900, the completion of the Observatory.

The initial equipment consists of a 12-inch Clark equatorial refractor, a three-inch transit, a sidereal clock and chronograph, and a six-foot focus Rowland concave grating spectroscope, with heliostat. The telescope is furnished with spectroscope for solar work, polarizing photometer, micrometer, and small star spectroscope, all with electric illumination. Other minor instruments are already purchased, and it is intended to provide less costly

apparatus in duplicate for the elementary practice of laboratory divisions.

The opening exercises were in the beautiful new Houghton Chapel. After the entrance of the academic procession led by the vested choir of the college, and an organ voluntary by the professor of music, Professor Hazard introduced Professor E. C. Pickering, who gave the address. He chose for his subject, "The New Planet Eros," and treated it most happily. He spoke of the discovery of the Asteroids, of the early patient work done upon them, of their late embarrassing number, so that Asteroid hunting seemed a doubtful reward, until this little object was found coming periodically into our near neighborhood, so that observations for its exact position might throw light upon vexed astronomical questions. He related the story of the computation of its orbit by Professor Chandler, based upon positions obtained from photographic plates by the patient scrutiny of Mrs. Fleming, and he told of the plans for observation at the coming approach. The usual note of inspiration for genuine work for which the speaker is well known, pervaded the address, and may wisely set the standard for the new Observatory.

Professor David P. Todd of Amherst spoke by request on "Laboratory Work in Astronomy," a work which he has already done much to promote. He claims that it is the method by which that healthful interest in the science so essential to its future development, may be created. He criticised the method of teaching astronomy which has up to this time prevailed, as in direct antagonism to the fundamental principles of scientific education. He expressed the belief that students should be given apparatus by means of which they could test great principles, since rightness of principle in this work at first should take precedence of display of mere precision of result. This suggestive address held the close attention of the audience.

Letters of greeting were read from foreign women of eminence in astronomy: from Lady Huggins, Miss Agnes Clerke and Miss Dorothea Klumpke. The singing by the choir and audience of Addison's great hymn of nature, "The glorious firmament on high," concluded the academic exercises.

The guests followed by the students, crossed the meadow to the new building. The whole company gathered about the front entrance, where the key was presented by the donor to the president of the college with the words: "It gives me great pleasure to present this building to Wellesley College and the keys to you, her president. I do it in the hope that the telescope and other

instruments may inspire a love of astronomy and the Observatory become a factor in the higher education of the young women who come to Wellesley College." As Mrs. Whitin threw open the door the musical notes of the Wellesley cheer rose from the students crowding the hillside, and her name rang out at the end.

The guests next assembled in the library where the fire was lighted upon the hearth by a symbolic torch handed to the donor by President Hazard. In the torch, as was explained, were the simples of the field which stood for health of body, the fern for grace and beauty, the leaf of the oak and elm for peace and civic virtues, the laurel for the breath of fame, the pine for hope of immortality. To these were added rosemary for remembrance and pansies for thoughts. "With these holy associations we light this fire, that from this place where Sun and stars are to be observed, true life may ever aspire with the flame to the Author of this light." As the torch, lighted from a silver lamp fed with aqua vitæ, kindled the fire, the chorus burst into song, rendering verses written for the occasion to the tune Hendon:

Stars above that shine and glow
Have their image here below,
Flames that from the earth arise,
Still aspiring, seek the skies.

Upward with the flame we soar,
Learning ever more and more;
Light and love descend till we,
Heaven reflected here shall see.

The visiting astronomers then inscribed their names in the Observatory book, and all proceeded to an inspection of the building. Refreshments were served in the dome.

In the circle south of the building, upon a granite shaft, is a sundial, the gift of an English friend of one of the professors. It bears the inscription which is upon the sundial in the garden of Sir William and Lady Huggins, "Nil nisi caelesti radio." The motto on the stone course beneath the dome is "Night unto night showeth knowledge."

Classes in physical astronomy and mathematical astronomy are already proving the priceless value of these new facilities.

A FAITHFUL WORKER.

P. S. YENDELL.

Mr. David Flanery, a notice of whose death appears on page 400 of the POPULAR ASTRONOMY for September, was born in

Limerick, Ireland, February 16, 1828. He came to this country in 1847, remaining but a short time, and returning to Ireland. Several years later he returned to the United States. He had become an expert telegraph operator, and was employed in that capacity at several points in the state of Mississippi.

At the breaking out of the Civil War in 1861, Mr. Flanery was residing in Jackson, Mississippi, where he was superintendent of the Southwestern Telegraph Company. He volunteered at the first call of the Confederacy for soldiers, but was induced to retain his position, and when the Confederacy took control of the lines was appointed censor at Jackson. He remained in the telegraph service through the whole war, being frequently under fire in the course of his duty.

In 1865, after the war ended, Mr. Flanery came to Memphis. He at once became permanently identified with the telegraph service, and in 1870 was appointed manager of the New Orleans offices of the Western Union. He was afterward manager at Richmond, Virginia. He returned to Memphis in 1870, and remained there until his death in August last.

Besides being an expert operator, Mr. Flanery was a scientific electrician, well known to the electrical world by his contributions to technical literature, and by several important inventions. His life was a busy and active one up to the last few weeks of his illness. It was only when he was too frail for active duty that he consented to leave his desk at the Western Union office.

Aside from his mastery of electrical science, he was to the end a student of astronomy, and was for many years a contributor to the popular astronomical periodicals.

It was in this connection that I first heard from him, early in the nineties, in a letter inquiring for information regarding certain variable stars. The exchange of letters grew into a sustained correspondence, which continued from the year 1895 till within four weeks of his death. He was a constant and regular correspondent, and I have many postal cards sent to keep me informed as to his latest observations of stars in which we were both interested.

He was a very persevering observer, disposed rather to attempt too much than too little, as is attested by the number of stars which he attempted to observe during his first year of this work, many of which were beyond the reach of his field-glass, which, however, he had not at that time the means of knowing.

In a letter, the last but one received from him, dated 1900, June 30, he says: "I write chiefly to say I am alive after being as

near death's door as a man gets without being drawn in. So I have little to communicate, but I have notwithstanding kept up my observations of SU Cygni, not missing one on any favorable night." In a postal card of June 17 he says, "I am confined to my room, but slipped down stairs three steps to an eastern window last night, and had a view of SU Cygni." I had considered myself a rather persistent observer, but this puts me to shame.

Through the courtesy of his son, Mr. Charles M. Flanery, I have by me all his note-books for the years 1895 to 1900 inclusive. They contain in all some four thousand observations, on about eighty stars. In the first year many of these are mere identifications, but about a dozen stars were carefully and persistently followed as long as he lived.

Early in 1897 he purchased a small telescope, with a view to extending downward the range of his observations of variables, and also of making a course of observations of sun spots. This latter series was continued, as his son informs me that up to the day before his death, his daughter made the observations for him. The last entry of astronomical character is August 2, "Nothing on Sun."

An examination of these notes shows that the observations were made with very great care, and the notes are carefully and minutely kept. He was very solicitous in securing the best information accessible to him as to positions and magnitudes, and in taking every possible precaution against avoidable errors of observation.

Mr. Flanery received little attention or encouragement from the regular astronomers; what he did receive he repaid with a great gratitude and appreciation. He was exceedingly modest as to the value of his astronomical work, and never seemed to think it good enough for publication. In spite of all discouragements and difficulties, and the occupations of a busy life, he secured valuable lines of observations of a number of variable stars, the results of which I hope to make public at a later day.

DORCHESTER, Mass., 1900, Oct. 1.

THE DISCOVERY AND PERIOD OF A SMALL VARIABLE STAR IN THE CLUSTER M 13 HERCULIS.

BY E. E. BARNARD.

While engaged in micrometrical work on the stars in the great globular clusters, I have become deeply interested in the variable stars found by Professor Bailey on his photographs taken at

Arequipa, and a large number of observations of some of these stars has been secured and will be printed with the micrometrical work when it is issued.

The great cluster of *Hercules*, *M 13*, at first seemed to differ from the other globular clusters in having no variable stars within its boundaries. This seemed to be the case as late as 1898. About that time, however, Professor Bailey found two stars slightly variable among the outliers on the Harvard photographs. I have simply heard that such were found, but have seen nothing stated as to their position in the cluster so that they might be identified and observed. I therefore do not know of the location of any such variables, and have made no special search for such stars. During the micrometer measures, however, I have found a variable star just within the edge of the brightest part of the cluster.

This star was found from visual observations alone, and not from an examination of photographs. Indeed, the only photograph that I had seen up to the time of finding it that showed the star at all was the Potsdam photograph. Its region is burned out in the other photographs by over-exposure. I have identified the star as No. 216 of Scheiner's catalogue, measured on a photograph of *M 13*. Its position has been micrometrically measured with reference to other stars of the cluster.

Scheiner Nos. 205 and 216,
$14°.12$ (2) $21''.49$ (2).
Scheiner Nos. 183 and 216,
$129°.53$ (4) $17''.50$ (4).
Scheiner Nos. 373 and 216,
$288°.45$ (2) $55''.16$ (2).

The variation is about one entire magnitude, from the 13th to the 14th, or rather from the 14th to the 13th, because its normal condition is faint.

From observations covering an interval of 70 periods, from 1899, August 14, to 1900, August 7, I deduce a period of 5 days, 2 hours and 24 minutes ($5^d.10$). From approximate elements its light curve seems to be much like the ones found by Professor Bailey for the variables in *M 5 Libræ*. The rise in brightness is rapid and the decline relatively slow. The star takes about 1 day to rise to its maximum, and its decline occupies about 2½ or 3 days. The rise is therefore about 0.2 and the decline about 0.5, or 0.6 of the entire period.

The photographic magnitude given this star by Professor Scheiner is 12.4.

I have compared the light of the variable with No. 200 near and preceding it.

Following are the observations:

COMPARISON OF THE LIGHT OF THE VARIABLE (NO. 216) WITH NO. 200.

TIME: 6 hours slow of Greenwich.

1900, July	9	0^m.2	brighter than No. 200 at	11^h	35^m
	10	0 .1		11	10
	10	0 .4		14	0
	11	1 .0		9	40
	12	0 .7		10	10
	24	0 .1		10	0
	24	0 .1		12	25
	25	0 .1		9	15
	25	0 .0		10	20
	26	0 .7		12	0
	28	0 .3		9	15
	29	0 .1		9	10
	29	0 .1		10	55
	30	0 .0		9	45
	30	0 .1		12	0
	31	0 .7		8	50
	31	0 .7		10	10
Aug.	1	1 .0		10	10
	4	0 .1		8	15
	5	0 .7		12	0
	6	1 .0		8	35
	7	0 .5		8	15
	12	0 .5		8	35
	13	0 .1		8	50
	14	0 .0		8	5
	18	0 .1		8	25
	20	0 .1		8	00
	21	1 .0		8	40
	27	0 .6		7	35
	28	0 .3		9	00
Sept.	3	0 .1		7	20
	3	0 .2		7	50
	4	0 .1		7	15
	4	0 .2		8	0
	19	0 .2		10	10

This star was also at its maximum on August 14, 1899.

YERKES OBSERVATORY, August, 1900.

THE OBSERVATIONS OF EROS.*

It seems to us wise to communicate to you the opinion of the special commission appointed by the International Conference in the matter of two questions concerning the carrying out of the micrometric observations of the planet Eros.

* Circular No. 5 of the International Astrographic Conference, July, 1900, prepared by the President, M. Loewy, Paris, Oct. 10, 1900. Translated from the French by Miss I. Watson, Professor of French and German, Carleton College.

The members were unanimously of the opinions:

I. That it was preferable to every other mode of operation to determine the relative positions of the asteroid with regard to the neighboring stars by the aid of measures of rectilinear coordinates.

II. That it seemed best to adopt the 11th magnitude as the lowest limit of brightness for the stars of comparison, so as to avoid too great accidental errors and slight systematic errors.

Since the object of this research is to reach the greatest possible precision, we beg our co-laborers to use exceptional care in the determination of instrumental constants, and especially in the frequent verification of the thread of the screw which, in the observatories of the northern hemisphere could easily be done by the aid of observations on the group of *h* Persei (Krueger).

On account of the numerous gaps which are certain to occur during the winter months, it is important that each Observatory try to take the greatest possible advantage of every favorable evening. We therefore advise the astronomers who undertake observations at great hour-angles east and west, (Circular No. 2, ¶¶ *a* and *b*) not to be content with a single supplementary series, but to make several of them. They will thus increase the possibility of making the results, which are obtained on different parts of the globe correspond to the same physical instant; and besides, they will obtain a series of observations made under the best conditions of altitude and which, in a general way, will always be valuable from divers points of view. But the interval between the successive series could then be reduced to one hour.

As to the execution of photographic work, it is fitting to make the following remarks:

I. For the special series of plates of which the sole object is to furnish the positions of stars of comparison, and which should contain all the stars to the eleventh (11th) magnitude at least, we would advise making on the same plate two exposures of different duration, in such a way that each star shall be represented by two images, distant by about twenty seconds of arc in declination. The second exposure would have for its object on the one hand to render the the true images of the stars more recognizable; and on the other hand, to permit two series of measures to be made on images of different intensity.

With the instruments which are employed in the construction of the photographic chart of the heavens (aperture $0^m.33$) a duration of three minutes might be considered sufficient for obtaining the greater part of the stars of the 11th magnitude.

But since it will be interesting to go beyond this limit in order to meet all possible contingencies, such as the very considerable differences between photographic and visual magnitudes, or a diminution in the transparency of the air, or even, in certain cases, the difficulty of finding stars of comparison of the eleventh magnitude in the immediate vicinity of the planet, it seems to us more reasonable and prudent to adopt a duration of 6 minutes for the first exposure, and of 3 minutes for the second; as is the case in the construction of the photographic catalogue of the heavens.

II. With regard to the series of plates intended for the measures of the positions of the planet, it would be equally useful to make two successive exposures on the same plate, first by following a guide star, *i. e.* by holding the image of this star at the crossing of the threads of the guiding telescope; second by following the image of the planet; but since the faintness of the asteroid would render this operation too difficult, one could obtain the same result by giving to the image of the guide star a movement equal to that of the planet and in the opposite direction. One would thus have for the planet in the first case a slightly elongated image and in the second a circular image.

As a matter of information we can announce that the planet has been photographed at the observatories of Paris and Algiers, Oct. 4 and 6, by following a guide star for 3 minutes and that perfectly sharp and quite intense images have been thus obtained. It is then beyond question that the photographic observation of the asteroid can be accomplished under good conditions. At the two dates indicated the planet was judged at Paris to be of a brilliancy at least equal to that of a star of magnitude 10.5.

M. Joly also has informed us that he obtained images of the planet on the 24th of last September at the Observatory at Dublin with a 15-inch reflector and with exposures of six and of two minutes. Mr. Turner, of Oxford, tells us that he reached the same result with an exposure of one minute, and that the rapid motion of Eros gives no equation for difficulty.

For the purpose of assuring so far as possible the success of this important work in which about fifty observatories are taking part, it is essential to know the exact state of advancement of each of these contemplated operations. The executive committee would thus be in a position to meet the difficulties which might arise and to secure the measures necessary for filling up the accidental gaps in the realization of the plan of work followed.

Accordingly we beg the astronomers who participate in this enterprise to kindly send us reports of the successive degrees of

progress which they shall have accomplished in the different kinds of observation.

Here is a more complete list of the observatories which, after the publication of the preceding circulars have given their adherence: Berlin, Besancon, Brussels, Charlottesville, Christiania, Denver, Dublin, Evanston, Florence, Helsingfors, Konigsberg, Lisbon, Madison, Northfield, Oxford (Eng.), Padua, Palerma, Pulkova, Tachkent, Teramo, Yerkes.

Below will be found the continuation of the auxiliary tables intended to facilitate the observations and calculations for the months of January and February, 1901. We have added to it a little recapitulative schedule containing the principal data which permit the astronomer to inform himself on the general conditions of the observations. Especially there will be found the visual brilliancy of the planet Eros, calculated for various epochs. According to the estimates made by Messrs. Bigourdan, Henry, Luther and Millosevich the value 10.5 has been adopted for the apparent magnitude of the star Sept. 29, 1900. The other numbers have been deduced taking into account the angle of the phase by means of the empiric formula of Mr. E. C. Pickering, (Circular No. 49, Harvard College Observatory).

In order to facilitate the reduction of the meridian observations of the reference stars, we will furnish, for a certain number of fundamentals situated in the region traversed by Eros, the positions calculated at intervals of ten days, from September 15 to December 31, 1900, and based on Newcomb's catalogue of fundamental stars.

SUMMARY OF THE CONDITIONS OF OBSERVATION OF THE PLANET EROS.

Date.	Magnitude.	R. A.	Decl.	Meridian Passage.	Parallax.
1900, Sept. 29	10.50	$2^h\ 44^m$	$+44°\ 12'$	$14^h\ 10^m$	15″.1
9	10.30	2 43	+47 51	13 30	17 .0
19	10.06	2 36	+51 5	12 43	19 .0
29	9.81	2 21	+53 24	11 49	21 .1
Nov. 8	9.56	2 1	+54 21	10 50	23 .1
18	9.34	1 42	+53 38	9 51	24 .9
28	9.15	1 29	+51 20	9 0	26 .3
Dec. 8	9.05	1 27	+47 55	8 19	27 .3
18	9.02	1 36	+43 54	7 48	27 .8
28	9.04	1 54	+39 38	7 27	27 .9
Jan. 7	9.12	2 20	+35 20	7 14	27 .6
17	9.26	2 51	+31 5	7 5	27 .1
27	9.47	3 26	+26 55	7 0	26 .1
Feb. 6	9.71	4 2	+22 52	6 57	24 .9
16	9.97	4 40	+19 1	6 56	23 .4
26	10.24	5 17	+15 24	6 54	21 .9
Mar. 8	10.48	5 54	+12 3	6 51	20 .3

AN ANCIENT ASTRONOMICAL INSTRUMENT.

KURT LAVES.

Some years ago I happened to see in the Ethnological Museum at Berlin among a collection of East Indian curiosities a small rectangular board about three inches by four, to the middle point of which a chord of about ten inches was fastened. A number of knots were tied into the string and on the one side of the board some words in foreign characters were visible. The explanation given by the label, attached to this item of curiosity, was, that the board was used by the tribes of the west shore of East India, accustomed to sea-faring life, for the purpose of determining their latitudes at sea.

It is evident how the little device can be used for this purpose. Holding with the one hand the board in a vertical position, so that the longer edges are horizontal, the observer with his face to the North Star can bring the upper edge to pass through the star whilst the lower edge is touching the horizontal line all the time, keeping the middle point of the board level with his eye. Stretching the cord to the tip of his nose and marking this point, the observer will have approximately determined the length of one of the equal sides of the isosceles triangle, which has its vertex in the eye of the observer; its base is formed by the vertical line passing through the middle point of the board. I have said, that the string measures one of the sides and not the height of the triangle, since it is stretched to a point nearly half the length of the base below the vertex of the triangle. The facial differences of the different observers must have established such a strong personal equation, as to limit each observer to his own apparatus. If we assume for a moment, that the North Star actually coincides with the North Pole, we can imagine, that the ancient observers needed only to find on land the lengths of the string for a number of conspicuous land marks of the shore, to have a ready means of finding between the latitudes of which two standard places their boat was located. Indeed we know the base b and the side l of the isosceles triangle, we have, therefore, when we call the angle at the vertex L

$$\sin L/2 = \frac{b}{2l}$$

L will be the altitude of the North Star or the latitude of the observer in our hypothesis. The rudeness of the method is apparent with its many and conspicuous defects, still there is a certain ingenuity in this proceeding cognate to that displayed in the in-

vention of the gnomon. But there seems to be a serious difficulty when we give up our hypothesis, that the daily apparent orbit of the North Star is reduced to a point. It is obvious, that when we determine the reference points in the string from observations of the North Star in upper culmination, we would arrive at absolutely erroneous results. The same is true when the star is in lower culmination. We can hardly assume, that the ancient observers had provided for that purpose a table of correction. A much simpler explanation appears to me to be the following: The great monsoon winds always occur at the same seasons of the year once in a southward, and once in a northward direction. Upon them communications between distant tribes of the East Indian shore have been dependent from times immemorial. Their two seasons are half a year apart and begin with January and July respectively. In the early evening hours of January, the Pole Star is near its upper culmination, in July near its lower culmination. If the ancient navigators were provided therefore, for the southward trip in January, with a set of reference points based upon observations in upper culmination, and for their northward journey in July with one derived from lower culmination, it seems that the difficulty would be easily remedied. It would seem therefore not improbable, that the little instrument in the Berliner Museum was invented for the very purpose of making possible these great and periodical journeys to distant shores. Since the East Indian peninsula lies between + 25° aud + 70° it is obvious that in these low latitudes the instrument is at its best, in as much as a small change in latitude will produce an appreciable change in the length of the string. Indeed

$$\frac{1}{\sin\frac{L}{2}}$$

varies between 5 and 11 in this interval of latitudes from 25° to 7° so the string at Cap Camorin will be about 16 inches with $b = 3$ inches and at the mouth of the Indus about 7 inches.

THE UNIVERSITY OF CHICAGO,
1900 Oct. 30th.

BURCKHALTER'S APPARATUS FOR PHOTOGRAPHING THE SOLAR CORONA.*

Charles Burckhalter's successful invention which enabled him to secure such excellent photographs at the Georgia eclipse last

* Extracts from an article that recently appeared in the *Oakland Inquirer*.

May is bringing much favorable notice both to himself and the Chabot Observatory of Oakland, with which he is connected. The leading astronomers of the world unite in declaring that Professor Burckhalter's invention is an important addition to the science and that it will probably lead to discoveries in the study of the Sun's corona.

As has been noted before, Professor Burckhalter's invention consists of a device whereby both the brighter and darker portions of the Sun's corona may be photographed at the same time. Professor Burckhalter was able to give his invention a thorough test at the Georgia eclipse last May, thanks to the generosity of John Dolbeer, a San Francisco business man who takes much interest in astronomy and who provided the necessary funds for the expedition. William M. Pierson of San Francisco had previously presented a photographic telescope to Chabot Observatory and Dr. George C. Purdee of Oakland had provided a duplicate lens and both of these instruments were taken to Georgia for use in the eclipse, most successful results being obtained, as can be judged from the extracts of letters from the astronomers given below.

Professor C. A. Young of Princeton Observatory, writes as follows:

"I congratulate you most heartily on your practically perfect success. All six of your revolver plates are admirable and the way in which different exposures and developments of positives made from a single negative bring out quite different details is very interesting, as exemplified in the two pairs of pictures made from your negatives 7 and 8."

Professor George E. Hale, director of the Yerkes Observatory, has the following to say:

"Many thanks for your kindness in sending the lantern slides of your photographs of the corona. They certainly show very clearly the advantage of your method of exposing and I only wish it were not too late to publish them with the other eclipse photographs in the *Astronomical Journal.*"

Professor E. C. Pickering of Harvard College Observatory says:

"Your letter and the lantern slides arrived safely. The latter are very interesting and ought to give us many new facts regarding the corona."

Professor J. E. Keeler, the late director of Lick Observatory, wrote shortly before his death as follows concerning the results of Professor Burckhalter's work at the Georgia eclipse:

"I congratulate you heartily on the success of your method and the final results you have obtained with it. While the the corona is less interesting than that of the India eclipse, your negatives are technically more perfect than those secured on that occasion."

Professor A. O. Leuschner, who is in charge of the students' Observatory of the University of California, had this to say:

"Please accept my sincere thanks for the fine slides from your photographs of the recent solar eclipse. There is no doubt in my mind that your method of obtaining composite photographs of the solar corona is an immense success and I extend to you my sincere congratulations on your fine work."

Captain William Noble, a prominent member of the Royal Astronomical Society of England, expressed himself as follows:

"I am delighted with them—there is no other word for it—and thank you most sincerely for so really beautiful and valuable a gift. It seems invidious to pick out one when all are so excellent, but I gravely doubt if 'No. 1' has ever been surpassed as a picture of the region immediately surrounding the Sun's limb, or 'No. 6' as a view of the entire solar surroundings. You ought to feel most uncommonly proud of yourself and of your really brilliant and original invention."

In writing concerning the sending of copies of Professor Burckhalter's photographs of the eclipse to Flammarion, the great French astronomer, M. J. Costa, the Consul of Uruguay at San Francisco, says:

"It is a pleasure to me to notify you that the great astronomer, Camille Flammarion, has received, through J. C. Cebrian, your photographs of the Sun's corona and he has pronounced them the best he has seen and he is going to print them in his paper, (*Astronomie Popularie*). He will write you about some details of said photographs."

Dr. L. Weinek, director of the Royal Observatory of Prague, Austria, says:

"I must confess that I have never seen such clear eclipse photographs with protuberances and a perfectly sharp rim of the Moon * * * * and I congratulate you upon the wonderful, astonishingly beautiful results."

In writing to John Dolbeer, who furnished the funds for the Chabot expedition Dr. Weinek said:

"At your kind suggestion, Mr. Charles Burckhalter, director of Chabot Observatory, Oakland, has sent me five splendid positives of this year's total eclipse of May 28th, taken at Siloam,

Georgia; they arrived here on September 29th in perfect condition. I am exceedingly gratified to possess these pictures which show the corona in an incomparably beautiful and clear manner. I congratulate you upon your great-heartedness in sending this expedition as well as Mr. Burckhalter upon the wonderful results obtained by his method of control. I have never seen even on the best eclipse photographs taken in any country and by any astronomers, the corona as a whole with the protuberances as they are shown in numbers 6 and 8. The protuberances on number 10 also show a surprising sharpness and distinctness."

Professor Edward S. Holden, formerly director of Lick Observatory, who is now in New York, expressed himself in the following enthusiastic manner:

"I've just received your splendid box of slides and given some little time to examining them. They are most instructive and do you the greatest credit. It is all your own plan, invented throughout and carried out unaided and these slides are a positive addition to science. I mean to study them in connection with other slides I have in New York and expect to learn much. The detail is wonderful and they are a success. I thank you sincerely for the chance of seeing them and congratulate you heartily."

W. H. Wesley, secretary of the Royal Astronomical Society, England, wrote, "the detail near the Moon's limb is marvelous and shows the immense superiority of the method."

Highly commendatory articles have also appeared in various astronomical journals, testifying to the importance and value of Professor Burckhalter's invention.

ASTRONOMY.*

DR. A. A. COMMON.

The progress of the new astronomy is so closely bound up with that of photography that I shall briefly call to mind some of the many achievements in which photography has aided the astronomer.

Daguerre's invention in 1839 was almost immediately tried with the Sun and Moon, J. W. Draper and the two Bonds in America, Warren de la Rue in this country, and Foucault and

* Opening Address by Dr. A, A. Common, F. R. S., F. R. A. S., Chairman of the Department of Astronomy, at the Bradford meeting of the British Association for the Advancement of Science. Continued from page 424.

Fizeau in France, being among the pioneers of celestial photography; but no real progress seems to have been made until after the introduction of the collodion process. Sir John Herschel in 1847 suggested the daily self-registration of the sun-spots to supercede drawings; and in 1857 the De la Rue photo-heliograph was installed at Kew. From 1858-72 a daily record was maintained by the Kew photo-heliograph, when the work was discontinued. Since 1873 the Kew series has been continued at Greenwich, and is supplemented by pictures from Dehra Dun in India and from Mauritius. The standard size of the Sun's disc on these photographs has now been for many years 8 inches, though for some time a 12-inch series was kept up.

The first recorded endeavor to employ photography for eclipse work dates back to 1851, when Berowsky obtained a daguerreotype of the solar prominences during the total eclipse. From that date nearly every total eclipse of the Sun has been studied by the aid of photography.

In 1860 the first regularly planned attack on the problem by means of photography was made, when De la Rue and Secchi successfully photographed the prominences and traces of the corona, but it was not until 1869 that Professor Stephen Alexander obtained the first good photograph of the corona.

In recent years, from 1893 until the total eclipse which occurred last May, photography has been employed to secure large-scale pictures of the corona. These were inaugurated in 1893 by Professor Schaeberle, who secured a 4-inch picture of the eclipsed Sun in Chilli; these have been exceeded by Professor Langley, who obtained a 15-inch picture of the corona in North Carolina during the eclipse of May 1900.

Photography also supplied the key to the question of the prominences and corona being solar appendages, for pictures of the eclipse Sun taken in Spain in 1860 terminated this dispute with regard to the prominences, and finally to the corona in 1871.

In 1875, in addition to photographing the corona, attempts were made to photograph its spectrum, and at every eclipse since then the sensitised plate has been used to record both the spectrum of the chromosphere and the corona. The spectrum of the lower layers of the chromosphere were first successfully photographed during the total eclipse of 1896 in Nova Zembla by Mr. Shackleton, though seen by Young as early as 1870 and a new value was given to the wave-length of the coronal line (wrongly mapped by Young in 1869) from photographs taken by Mr.

Fowler during the eclipse of 1898 (India).

Lunar photography has occupied the attention of various physicists from time to time, and when Daguerre's process was first enunciated, Arago proposed that the lunar surface should be studied by means of the photographically produced images. In 1840 Dr. Draper succeeded in impressing a daguerreotype plate with a lunar image by the aid of a 5-inch refractor. The earliest lunar photographs, however, shown in England, were due to Professor Bond, of the United States. These he exhibited at the Great Exhibition in 1851. Dancer, the optician, of Manchester, was, perhaps, the first Englishman who secured lunar images, but they were of small size (Abney, "Photography.)"

Another skillful observer was Crookes, who obtained images of 2 inches diameter, with an 8-inch refractor of the Liverpool Observatory. In 1852 De la Rue began experimenting in lunar photography. He employed a reflector of some 10 feet focal length and about 13 inches diameter. A very complete account of his methods is given in a paper read before the British Association. Mr. Rutherfurd at a later date having tried an 11½-inch refractor, and also a 13-inch reflector, finally constructed a photographic refracting telescope, and produced some of the finest pictures of the Moon that were ever taken until recent years. Also Henry Draper's picture of the Moon taken Sept. 3, 1863, remained unsurpassed for a quarter of a century.

Admirable photographs of the lunar surface have been published in recent years by the Lick Observatory and others. I myself devoted considerable attention to this subject at one time; but only those surpassing anything before attempted have been published in 1896-99 by MM. Loewy and Puiseux, taken with the Equatorial Coude of the Paris Observatory.

Star prints were first secured at Harvard College, under the direction of W. C. Bond, in 1850; and his son, G. P. Bond, made in 1857 a most promising start with double-star measurements on sensitive plates, his subject being the well-known pair in the tail of the Great Bear. The competence of the photographic method to meet the stringent requirements of exact astronomy was still more decisively shown in 1866 by Dr. Gould's determination from his plates of nearly fifty stars in the Pleiades. Their comparison with Bessel's places for the same objects proved that the lapse of a score of years had made no difference in the configuration of that immemorial cluster; and Professor Jacoby's recent measures of Rutherfurd's photographs taken in 1872 and 1874 enforce the same conclusion.

The above facts are so forcible that no wonder that at the Astrophotographic Congress held in Paris in 1887 it was decided to make a photographic survey of the heavens, and now eighteen photographic telescopes of 13 inches aperture are in operation in various parts of the world, for the purpose of preparing the international astrographic chart, and it was hoped that the catalogue plates would be completed by 1900.

Photography has been applied so assiduously to the discovery of minor planets that something like 450 are now known, the most noteworthy, perhaps, as regards utility being the discovery of Eros (433) in 1898 by Herr Witt at the Observatory Urania, near Berlin.

With regard to the application of photography to recording the forms of various nebulæ, it is interesting to quote a passage from Dick's "Practical Astronomer," published in 1845, as opposed to Herschel's opinion that the photography of a nebula would never be possible.

"It might, perhaps, be considered as beyond the bounds of probability to expect that even the distant nebulæ might thus be fixed, and a delineation of their objects produced, which shall be capable of being magnified by microscopes. But we ought to consider that the art is only in its infancy, and that plates of a more delicate nature than those hitherto used may yet be prepared, and that other properties of light may yet be discovered, which shall facilitate such designs. For we ought now to set no boundaries to the discoveries of science, and to the practical applications of scientific discovery, which genius and art may accomplish."

It was not, however, until 1880 that Draper first photographed the Orion Nebula, and later by three years I succeeded in doing the same thing with an exposure of only thirty-seven minutes. In December 1885 the brothers Henry by the aid of photography found that the Pleiades were involved in a nebula, part of which, however, had been seen by myself (*Monthly Notices*, vol. xl. p. 376) with my 3-foot reflector in February 1880, and later, February 1886; it was also partly discerned at Pulkowa with the 30-inch refractor then newly erected.

Still more nebulosity was shown by Dr. Roberts's photographs (*ibid.*, vol. xlvii, p. 24), taken with his 20-inch reflector in October and December 1886, when the whole western side of the group was shown to be involved in a vast nebula, whilst a later photograph taken by MM. Henry early in 1888 showed that practically the whole of the group was a shoal of nebulous matter.

In 1881 Draper and Janssen recorded the comet of that year by photography.

Huggins (*Proc. Roy. Soc.*, vol. xxxii. No. 213) succeeded in photographing a part of the spectrum of the same object (Tebbutt's Comet 1881, II.) on June 24, and the Fraunhofer lines were amongst the photographic impressions, thus demonstrating that at least a part of the continuous spectrum is due to reflected sunlight. He also secured a similar result from Comet Wells (*Brit. Assoc. Report*, 1882, p. 442).

I propose to consider the question of the telescope on the following lines: (1) The refractor and reflector from their inception to their present state. (2) The various modifications and improvements that have been made in mounting these instruments, and (3) the instrument that has lately been introduced by a combination of the two, refractor and reflector, a striking example of which exists now at the Paris Exhibition.

At a meeting of the British Association held nearly half a century ago (1852) (Belfast) Sir David Brewster showed a plate of rock crystal worked in the form of a lens which had been recently found in Nineveh. Sir David Brewster asserted that this lens had been destined for optical purposes, and that it never was a dress ornament.

That the ancients were acquainted with the powers of a magnifying lens may be inferred from the delicacy and minuteness of the incised work on their seals and intaglios, which could only have been done by an eye aided by a lens of some sort.

There is, however, no direct evidence that the ancients were really acquainted with the refracting telescope, though Aristotle speaks of the tubes through which the ancients observed distant objects, and compares their effect to that of a well from the bottom of which the stars may be seen in daylight ("De Gen. Animalium," lib. v). As an historical fact without any equivocations, however, there is no serious doubt that the telescope was invented in Holland.

The honor of being the originator has been claimed for three men, each of whom has had his partisans. Their names are Metius, Lippershey and Janssen.

Galileo himself says that it was through hearing that some one in France or Holland had made an instrument which magnified distant objects that he was led to inquire how such a result could be obtained.

The first publisher of a result or discovery, supposing such discovery to be honestly his own, ranks as the first inventor, and

there is little doubt that Galileo was the first to show the world how to make a telescope (Newcomb's "Astronomy," p. 108). His first telescope was made whilst on a visit to Venice, and he there exhibited a telescope *magnifying three times*: this was in May, 1609. Later telescopes which emanated from the hands of Galileo magnified successively four, seven and thirty times. This latter number he never exceeded.

Greater magnifying power was not attained until Kepler explained the theory and some of the advantages of a telescope made of two convex lenses in his "Catoptrics" (1611). The first person to actually apply this to the telescope was Father Scheiner, who describes it in his "Rosa Ursina" (1630) and Wm. Gascoigne was the first to appreciate practically the chief advantages by his invention of the micrometer and application of telescopic sights to instruments of precision.

It was, however, not until about the middle of the seventeenth century that Kepler's telescope came to be nearly universal, and then chiefly because its field of view exceeded that of the Galilean.

The first powerful telescopes were made by Huyghens, and with one of these he discovered Titan (Saturn's brightest satellite): his telescopes magnified from forty-eight to ninety-two times, were about 2⅓ inches aperture, with focal lengths ranging from 12 to 23 feet. By the aid of these he gave the first explanation of Saturn's ring, which he published in 1659.

Huyghens also states that he made object-glasses of 170 feet and 210 feet focal length; also one 300 feet long, but which magnified only 600 times; he also presented one of 123 feet to the Royal Society of London.

Auzout states that the best telescopes of Campani at Rome magnified 150 times, and were of 17 feet focal length. He himself is said to have made telescopes of from 300 to 600 feet focus, but it is improbable that they were ever put to practical use. Cassini discovered Saturn's fifth satellite (Rhea) in 1672, with a telescope made by Campani, magnifying about 150 times, whilst later, in 1684, he added the third and fourth satellites of the same planet to the list of his discoveries.

Although these telescopes were unwieldy, Bradley, with his usual persistency, actually determined the diameter of Venus in 1722 with a telescope of 212 feet focal length.

With such cumbersome instruments many devices were invented of pointing these *aerial telescopes*, as they were termed, to various parts of the sky. Huyghens contrived some ingenious arrangements for this purpose, and also for adjusting and centre-

ing the eye-piece, the object-glass and eye-piece being connected by a long braced rod.

It was not, however, until Dolland's invention of the achromatic object-glass in 1757-58 that the refracting telescope was materially improved, and even then the difficulty of obtaining large blocks of glass free from striæ limited the telescope as regards aperture, for even at the date of Airy's report we have seen that 12 inches was about the maximum aperture for an object-glass.

The work of improving glass dates back to 1784, when Guinand began experimenting with the manufacture of optical flint glass.

He conveyed his secrets to the firm of Fraunhofer and Utzschneider, whom he joined in 1805, and during the period he was there they made the 9.6-inches object-glass for the Dorpat telescope.

Merz and Mædler, the successors of Fraunhofer, carried out successfully the methods handed down to them by Guinand and Fraunhofer.

Guinand communicated his secrets to his family before his death in 1823, and they entered into partnership with Bontemps. The latter afterwards joined the firm of Chance Bros., of Birmingham, and so some of Guinand's work came to England.

At the present day MM. Feil, of Paris, who are direct descendants of Guinand and Messrs. Chance Bros., of Birmingham, are the best known manufacturers of large discs of optical glass.

It is related in history that Ptolemy Euergetes had caused to be erected on a lighthouse at Alexandria a piece of apparatus for discovering vessels a long way off; it has also been maintained that the instrument cited was a concave reflecting mirror, and it is possible to observe with the naked eye images formed by a concave mirror, and that such images are very bright.

Also the Romans were well acquainted with the concentrating power of concave mirrors, using them as burning mirrors, as they were called. The first application of an eye lens to the image formed by reflection from a concave mirror appears to have been made by Father Zucchi, an Italian Jesuit. His work was published in 1652, though it appears he employed such an instrument as early as 1616. The priority, however, of describing, if not making, a practical reflecting telescope belongs to Gregory, who, in his "Optica Promota," 1663, discusses the forms of images of objects produced by mirrors. He was well aware of the failure of all attempts to perfect telescopes by using

lenses of various curvature, and proposed the form of reflecting telescope which bears his name.

Newton, however, was the first to construct a reflecting telescope, and with it he could see Jupiter's satellites, etc. Encouraged by this, he made another of 6½-inches focal length, which magnified thirty-eight times, and this he presented to the Royal Society on the day of his election to the Society in 1671.

To Newton we owe also the idea of employing pitch, used in the working of the surfaces.

A third form of telescope was invented by Cassegrain in 1672. He substituted a small convex mirror for the concave mirror in Gregory's form, and thus rendered the telescope a little shorter.

Short, also from 1730-68, displayed uncommon ability in the manufacture of reflecting telescopes, and succeeded in giving true parabolic and elliptic figures to his specula, besides obtaining a high degree of polish upon them. In Short's first telescopes the specula were of glass, as suggested by Gregory; but it was not until after Liebig's discovery of the process of depositing a a film of metallic silver upon a glass surface from a salt in solution that glass specula became almost universal, and thus replaced the metallic ones of earlier times.

Shortly after the announcement of Liebig's discovery Steinheil (*Gaz. Univ. d'Augsburg*, March 24, 1856)—and later, independently, Foucault, (*Comptes rend.*, Vol. XLIV, February 1857)—proposed to employ glass for the specula of telescopes, and as is well known, this is done in all the large reflectors of to-day.

I now propose to deal with the various steps in the development of the telescope, which have resulted in the three forms that I take as examples of the highest development at the present time. These are the Yerkes telescope at Chicago, my own 5-foot reflector, and the telescope recently erected at the Paris Exhibition, dealing not only with the mountings, but with the principles of construction of each. When the telescope was first used all could be seen by holding it in the hand. As the magnifying power increased, some kind of support would become absolutely necessary, and this would take the form of the altitude and azimuth stand, and the motion of the heavenly bodies would doubtless suggest the parallactic or equatorial movement, by which the telescope followed the object by one movement, of an axis placed parallel to the pole. This did not come, however, immediately. The long focus telescopes of which I have spoken were sometimes used with a tube, but more often the object-glass was mounted in a long cell and suspended from the top of a pole

at the right height to be in a line between the observer and the object to be looked at; and it was so arranged that by means of a cord it could be brought into a fairly correct position. Notwithstanding the extreme awkwardness of this arrangement, most excellent observations were made in the seventeenth century by the users of these telescopes. Then the achromatic telescope was invented and mechanical mountings were used, with circles for finding positions, much as we have them now. I have already mentioned the rivalry between the English and German forms of mountings, and Airy's preference for the English form. The general feeling amongst astronomers has, however, been largely in favor of the German mounting for refractors, due, no doubt, to a great extent, to the enormous advance in engineering skill. We have many examples of this form of mounting. * * *

The small reflector made by Sir Isaac Newton, probably the first ever made, and now at the Royal Society, is mounted on a ball, gripped by two curved pieces, attached to the body of the telescope, which allows the telescope to be pointed in any direction. We have not much information as to the mounting of early reflectors. Sir William Herschel mounted his 4-foot telescope on a rough but admirably planned open-work mounting, capable of being turned round, and with means to tilt the telescope to any required angle. This form was not very suitable for picking up objects or determining their position, except indirectly; but for the way it was used by Sir William Herschel it was most admirably adapted: the telescope being elevated to the required angle, it was left in that position, and became practically a transit instrument. All the objects passing through the field of view (which was of considerable extent, as the eye-piece could not be moved in declination) were observed, and their places in time and declination noted, so that the positions of all these objects in the zone observed were obtained with a considerable degree of accuracy. It was on this plan that Sir John Herschel made his general catalogue of nebulæ, embracing all the nebulæ he could see in both hemispheres; a complete work by one man that is almost unique in the history of astronomy.

Sir William Herschel's mounting of his 4-foot reflector differs in almost every particular from the mountings of the long focus telescopes we have just spoken of. The object-glass was at a height, the reflector was close to the ground. There was a tube to one telescope, but not to the other. The observer in one case stood on the ground, in the other he was on a stage at a considerable elevation. One pole sufficed with a cord for one; a

whole mass of poles, wheels, pulleys and ropes surrounded the other. In one respect only were they alike—they both did fine work.

Lassell seems to have been the first to mount a reflector equatorially. He, like Herschel, made a 4-foot telescope, and this he mounted in this way. Lord Rosse mounted his telescopes somewhat after the manner of Sir William Herschel. The present Earl has mounted a 3-foot equatorially.

A 4-foot telescope was made by Thomas Grubb for Melbourne, and this he mounted on the German plan. The telescope being a Cassegrain, the observer is practically on the ground level. A somewhat similar instrument exists at the Paris Observatory. Lassell's 4-foot was mounted in what is called a fork mounting, as is also my own 5-foot reflector, and this in some ways seems well adapted for reflectors of the Newtonian kind.

We now come to the Paris telescope. This is really the result of the combination of a reflector and a refractor. I cannot say when a plane mirror was first used to direct the light into a telescope for astronomical purposes. It seems first to have been suggested by Hooke, who, at a meeting of the Royal Society, when the difficulty of mounting the long focus lenses of Huyghens was under discussion, pointed out that all difficulties would be done away with if, instead of giving movement to the huge telescope itself, a plane mirror were made to move in front of it (Lockyer, "Star-gazing," p. 453).

The Earl of Crawford, then Lord Lindsay, used a heliostat to direct the rays from the Sun, on the occasion of the transit of Venus, through a lens of 40 feet focal length, in order to obtain photographs, and it was also largely used by the American observers on the same occasion.

Monsieur Loëwy at Paris proposed in 1871 a most ingenious telescope made by a combination of two plane mirrors and an achromatic object-glass, which he calls a Coudé telescope, which has some most important advantages. Chief amongst these are that the observer sits in perfect comfort at the upper end of the polar axis, whence he need not move, and by suitable arrangements he can direct the telescope to any part of the visible heavens. Several have been made in France, including a large one of 24 inches aperture, erected at the Paris Observatory, and which has already made its mark by the production of perhaps the best photographs of the Moon yet obtained. I have already spoken of Lord Lindsay and his 40-foot telescope, fed, as it were with light from a heliostat. This is exactly the plan that has been fo

lowed in the design of the large telescope in the Paris Exhibition. But in place of a lens of 4 inches aperture and a heliostat a few inches larger, the Paris telescope has a plane mirror of 6 feet and a lens exceeding 4 feet in diameter, with a focal length of 186 feet. The cost of a mounting on the German plan and of a dome to shelter such an instrument would have been enormous. The form chosen is at once the best and cheapest. One of the great disadvantages is that from the nature of things it cannot take in the whole of the heavens. The heliostat form of mounting of the plane mirror causes a rotation of the image in the field of view which in many lines of research is a strong objection. There is much to be said on the other side. The dome is dispensed with, the tube, the equatorial mounting and the rising floor are not wanted. The mechanical arrangements of importance are confined to the mounting of the necessary machinery to carry the large plane mirror and move it round at the proper rate. The telescope need not have any tube (that to the Paris telescope is, of course, only placed there for effect) as the flimsiest covering is enough if it excludes false light falling on the eye-end; and, more important than all, the observer sits at his ease in the dark chamber. This question of the observer, and the conditions under which he observes, is a most important one as regards both the quality and quantity of the work done.

We have watched the astronomer, first observing from the floor level, then mounted on a high scaffold like Sir William Herschel, Lassell and Lord Rosse; then, starting again from the floor level and using the early achromatic telescope; then, as these grew in size, climbing up on observing chairs to suit the various positions of the eye-end of the telescope, as we see in Mr. Newall's great telescope; then brought to the floor again by that excellent device of Sir Howard Grubb, the rising floor. This is in use with the Lick and the Yerkes telescopes, where the observer is practically always on the floor level, though constant attention is needed, and the circular motion has to be provided for by constant movement, to say nothing of the danger of the floor going wrong. Then we have the ideal condition, as in the Equatorial Coudé at the Paris Observatory, where the observer sits comfortably sheltered and looks down the telescope, and from this position can survey the whole of the visible heavens. The comfort of the observer is a most important matter, especially in the long exposures that are given to photographic plates, as well as for continued visual work. In such a form of telescope as that at Paris, the heliostat form of mounting the

plane mirror is most suitable, notwithstanding the rotation of the image. But there is another way in which a plane mirror can be mounted, and that is on the plan first proposed by Auguste many years ago and lately brought forward again by Mons. Lippman, of Paris, and that is by simply mounting the plane mirror on a polar axis and parallel therewith, and causing his mirror to rotate at half the speed of the Earth's rotation. Any part of the heavens seen by any person reflected from his mirror will appear to be fixed in space, and not partake of the apparent movement of the Earth, so long as the mirror is kept moving at this rate. A telescope, therefore, directed to such a mirror can observe any heavenly body as if it were in an absolutely fixed position so long as the angle of the mirror shall not be such as to make the reflected beam less than will fill the object-glass. There is one disadvantage in the cœlostat, as this instrument is called, and that is its suitability only for regions near the equator. The range above and below, however, is large enough to include the greater portion of the heavens, and that portion in which the solar system is included. Here the telescope must be moved in azimuth for different portions of the sky, as is fully explained by Professor Turner in Vol. LVI of the *Monthly Notices*, and it therefore becomes necessary to provide for moving the telescope in azimuth from time to time as different zones above or below the equator are observed. No instrument yet devised is suitable for all kinds of work, but this form, notwithstanding its defects, has so many and such important advantages that I think it will obviate the necessity of building any larger refractors on the usual models. The cost of producing a telescope much larger than the Yerkes on that model, in comparison with what could be done on the plan I now advocate, renders it most improbable that further money will be spent in that way. It may be asked, What are the lines of research which could be taken up by a telescope of this construction, and on what lines should the telescope be built? I will endeavor to answer this. All the work that is usually done by an astronomical telescope, excepting very long continued observations, can be equally well done by the fixed telescope. But there are some special lines for which this form of research is admirably suited, such as photographs of the Moon, which would be possible with a reflecting mirror, of say, 200 feet focal length, giving an image of some 2 feet diameter in a primary focus, or a larger image might be obtained either by a longer focus miror or by a combination. It might even be worth while to build a special cœlostat for lunar photography, provided with an adjustment to the polar axis

and a method of regulating the rate of clock to correct the irregular motion of the Moon, and thus obtain absolutely fixed images on the photographic plate.

The advantage of large primary images in photography is now fully recognized. For all other kinds of astronomical photography a fixed telescope is admirably adapted; and so with all spectroscopic investigations, a little consideration will show that the conditions under which these investigations can be pursued are almost ideal. As to the actual form such a construction would take, we can easily imagine it. The large mirror mounted as a cœlostat in the center; circular tracks round this center, on which a fan-shaped house can be travelled round to any azimuth, containing all the necessary apparatus for utilising the light from the large plane mirror, so as to be easily moved round to the required position in azimuth for observation. In place of a fan-shaped house movable round the plane mirror, a permanent house might encircle the greater portion round the mirror, and in this house the telescope or whatever optical combination is used might be arranged on an open framework, supported on similar rails, so as to run round to any azimuth required. The simplicity of the arrangement and the enormous saving in cost would allow in any well-equipped Observatory the use of a special instrument for special work. The French telescope has a mirror about 6 feet in diameter and a lens of about 4 feet. This is a great step in advance over the Yerkes telescope, and it may be some time before the glass for a lens greater than 50 inches diameter will be made, as the difficulty in making optical glass is undoubtedly very great. But with the plane mirror there will be no such difficulty, as 6 feet has already been made; and so with a concave mirror there would be little difficulty in beginning with 6 feet or 7 feet. The way in which the mirror would be used, always hanging in a band, is the most favorable condition for good work, and the absence of motion during an observation, except of course that of the plane mirror (which could be given by floating the polar axis and suitable mechanical arrangements, a motion of almost perfect regularity).

One extremely important thing in using silver or glass mirrors is the matter of resilvering from time to time. Up to quite recently the silvering of my 5-foot mirror was a long, uncertain and expensive process. Now we have a method of silvering mirrors that is certain, quick and cheap. This takes away the one great disability from the silver or glass reflecting telescope, as the surface of silver can now be renewed with greater ease and in less

time than the lenses of a large refracting telescope could be taken out and cleaned. It may be that we shall revert to speculum metal for our mirrors, or use some other deposited metal on glass; but even as it is we have the silvered glass reflector, which at once allows an enormous advance in power. To do justice to any large telescope it should be erected in a position, as regards climate, where the conditions are as favorable as possible.

The invention of the telescope is to me the most beautiful ever made. Familiarity both in making and in using has only increased my admiration. With the exception of the microphone of the late Professor Hughes, which enabled one to hear otherwise inaudible sounds, sight is the only sense that we have been able to enormously increase in range. The telescope enables one to see distant objects as if they were at, say, one-five-thousandth part of their distance, while the microscope renders visible objects so small as to be almost incredible. In order to appreciate better what optical aid does for the sense of sight, we can imagine the size of an eye, and therefore of a man, capable of seeing in a natural way what the ordinary eye sees by the aid of a large telescope, and, on the other hand, the size of a man and his eye that could see plainly small objects as we see them under a powerful microscope. The man in the first case would be several miles in height, and in the latter he would not exceed a very small fraction of an inch in height.

Photography also comes in as a further aid to the telescope, as it may possibly be to the microscope. For a certain amount of light is necessary to produce sensation in the eye. If this light is insufficient nothing is seen; but owing to the accumulative effect of light on the photographic plate, photographs can be taken of objects otherwise invisible, as I pointed out years ago, for in photographs I took in 1883 stars were shown on photographic plates that I could not see in the telescope. All photographs, when closely examined, are made up of a certain number of little dots, as it were, in the nature of stippling, and it is a very interesting point to consider the relation of the size and separation of these dots that form the image, and the rods and cones of the retina which determines the power of the eye.

Many years ago I tried to determine this question. I first took a photograph of the Moon with a telescope of very short focus (as near as I could get it to the focus of the eye itself, which is about half an inch). The resulting photograph measured one two-hundredth of an inch in diameter, and when examined again with a microscope showed a fair amount of detail, in fact,

very much as we see the Moon with the naked eye; making a picture of the Moon by hand on such a scale that each separate dot of which it was made corresponded with each separate sensitive point of the retina employed when viewing the Moon without optical aid, I found, on looking at this picture at the proper distance, that it looked exactly like a real Moon. In this case the distance of the dots was constant, making them larger or smaller forming the light or shade of the picture.

I did not complete these experiments, but as far as I went I thought that there was good reason to believe that we could in this way increase the defining power of the eye. It is a subject well worthy of further consideration.

I know that in this imperfect and necessarily brief address I have been obliged to omit the names of many workers, but I cannot conclude without alluding to the part that this Association has played in fostering and aiding Astronomy. A glance through the list of money grants shows that the help has been most liberal. In my youth I recollect the great value that was put on the British Association Catalogue of Stars; we know the help that was given in its early days to the Kew Observatory; and the Reports of the Association show the great interest that has always been taken in our work. The formation of a separate Department of Astronomy is, I hope, a pledge that this interest will be continued, to the advantage of our science.—*Nature.*

THE REFLECTOR IN AMERICA.

W. W. PAYNE.

Not long ago we received a reprint of an article prepared by the late Professor James E. Keeler, entitled "The Crossley Reflector of the Lick Observatory, with which were given several plates, explanatory of the instrument, and one illustrating its work as a photographic telescope. The object photographed was the Trifid nebula. The negative was taken July 6, 1899, with an exposure of three hours. In the article above referred to, Professor Keeler said that the negative "was not selected as a specimen of the work of the instrument, for it was made in the early stages of experiments, and the star images were not good, but rather on account of the interest of the subject."

The reproduction of the negative was by the photogravure process, and reported to be fairly successful. It was enlarged, as

compared with the original negative, 2.9 diameters (1 mm = 13 minutes of arc), the scale being somewhat greater than that used by Dr. Isaac Roberts of England, who photographed the same object, July 13, 1899, with a 20-inch reflector, giving his plate an exposure of ninety minutes. The scale used in the last named negative was 1 mm to twenty seconds of arc. The reproduction of the Lick negative appears to be better than that secured for the other. In the former the shading of the bright and faint parts of the nebula and the rifts in it are shown beautifully. The star-like points scattered all through the nebula come out in this cut with surprising distinctness. If these images were good, they are bright enough and sharp enough for measures for relative position, a most important point for the study of the drift of the nebula, if they are stars independent of the nebula; and also important in another way if they are only nebulous knots in the vast, rifted masses of nebulæ surrounding them.

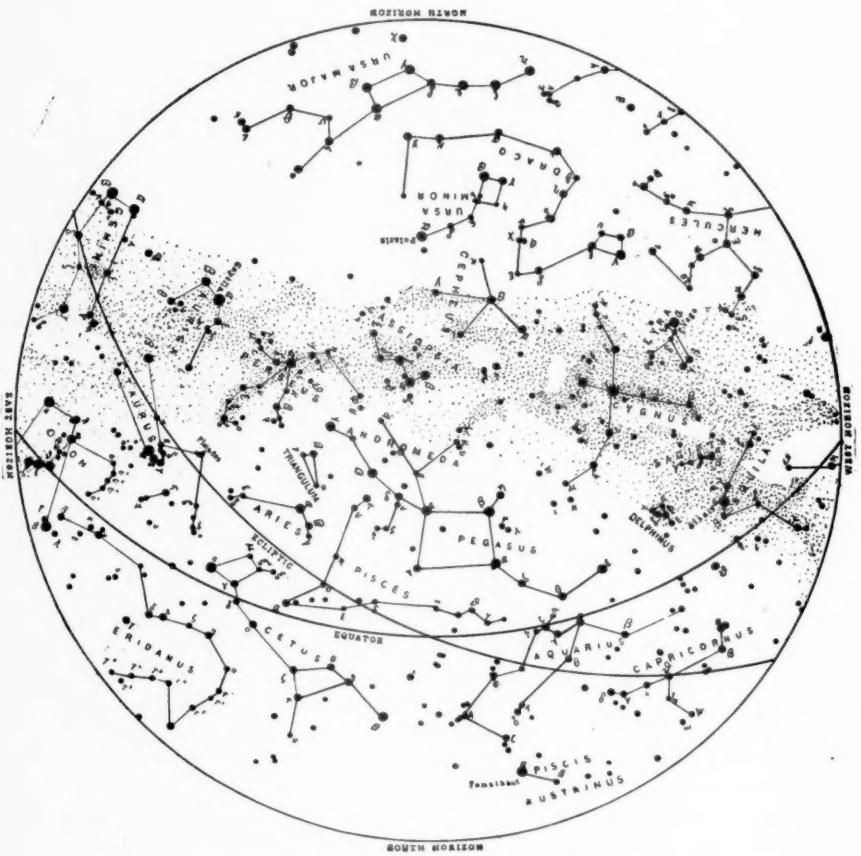
Some years ago, when a prominent astronomer was giving some attention to this nebula, he suggested that the position of one bright star in the edge of one of the three great rifts might be chosen as a reference star, for the purpose of determining whether or not this particular nebula is in motion with reference to the stars. Either of the negatives above referred to must give ample opportunity for such work in a much wider range than could have been expected by any astronomer a few years ago. This is due to the progress of photography as an aid in mapping faint objects and to the reflecting telescope as an instrument especially adapted to photograph such celestial objects in a way to secure a variety of details hitherto unknown.

The Crossley reflector of the Lick Observatory in the hands of so skillful an astronomer, as was the late Professor Keeler, has drawn general attention of American astronomers again to this kind of a telescope for photographic work. For common astronomical work Americans have generally preferred the refracting telescope, and the success of the American refractor for most kinds of observation has probably warranted the preference of astronomers on this side of the sea for the refractor. But the unexpected success that came from the limited use of the Crossley reflector in photographing difficult celestial objects, will certainly give the reflector a new and important place in the attention of astronomers in the west who are to devote themselves largely to photographic work.

PLANET NOTES FOR NOVEMBER.

H. C. WILSON.

Mercury will be at inferior conjunction on the morning of Nov. 20 and will be invisible in the rays of the Sun except for the first few days of the month.



THE CONSTELLATIONS AT 9 P. M., NOVEMBER 1, 1900.

Venus rises at about three o'clock in the morning and passes the meridian on Nov. 1 at $9^h\ 11^m$ A. M. local time. The planet is bright enough to be seen with the naked eye at any time during the forenoon, if one knows just where to look. Venus and the star η Virginis will be in conjunction Nov. 6 at noon, the star being

13′ south of the planet. The Moon and Venus will be in conjunction Nov. 18 at 7 P. M. Central Standard time, Venus then being nearly 6° north of the Moon.

Mars will be near the meridian from 6^h to 7^h in the morning and may be identified by early risers without difficulty, from its position in the constellation Leo and its ruddy color, contrasting strongly with the white blue light of Regulus. The planet will move southeast passing Regulus Nov. 17. Mars will be at quadrature, 90° west from the Sun, on the morning of Nov. 22.

Jupiter, *Saturn* and *Uranus* may still be seen toward the southwest very early in the evening, but at too low an altitude for satisfactory observation.

Neptune is like a star of the 8th magnitude in that part of the sky where the three constellations Taurus, Gemini and Orion meet. Its position Nov. 15 is R. A. $5^h\ 54^m\ 33^s$; Decl. + 22° 12′, and changes very little during the month.

The Moon.

Phases.		Rises. (Central Standard Time at Northfield; Local Time 13m less).	Sets.
		h m	h m
Nov. 6	Full Moon	4 41 P. M.	7 51 A. M.
13	Last Quarter	11 39 "	1 05 P. M.
22	New Moon	7 41 A. M.	4 59 "
29	First Quarter	12 26 P. M.	12 27 A. M.

Occultations Visible at Washington.

Date. 1900.	Star's Name.	Magnitude.	IMMERSION. Washington M. T.	IMMERSION. Angle from N pt.	EMERSION. Washington M. T.	EMERSION. Angle from N pt.	Duration.
			h m	°	h m	°	h m
Nov. 6	ρ^1 Arietis	7.0	6 17	24	6 54	299	0 37
6	50 Arietis	6.8	9 00	86	10 09	234	1 09
6	54 Arietis	6.3	13 10	27	13 59	308	0 49
7	B.A.C. 1242	6.3	7 45	49	8 37	289	0 52
7	ω^2 Tauri	5.7	16 06	118	17 06	242	1 00
11	1 Cancri	6.3	8 41	126	9 31	249	0 50
12	60 Cancri	6.0	13 24	181	13 44	213	0 20
12	α^2 Cancri	4.0	14 43	66	15 21	337	0 58
25	*d* Sagittarii	5.0	8 43	94	9 34	233	0 51
30	16 Piscium	5.8	4 30	47	5 43	253	1 13
30	19 Piscium	4.9	11 01	53	12 02	260	1 01

Annular Eclipse of the Sun.—On Nov. 21 at $19^h\ 22^m\ 49^s.0$, Greenwich Mean time, or on the morning of Nov. 22, Central Standard time, the Sun and Moon will be in conjunction and there will be an annular eclipse of the Sun. It will be visible only in South Africa and Australia and the islands in the vicinity of these countries. The following chart shows the path of the annulus and the region of partial eclipse. As there is no hope of the corona being visible, but little interest attaches to this eclipse.

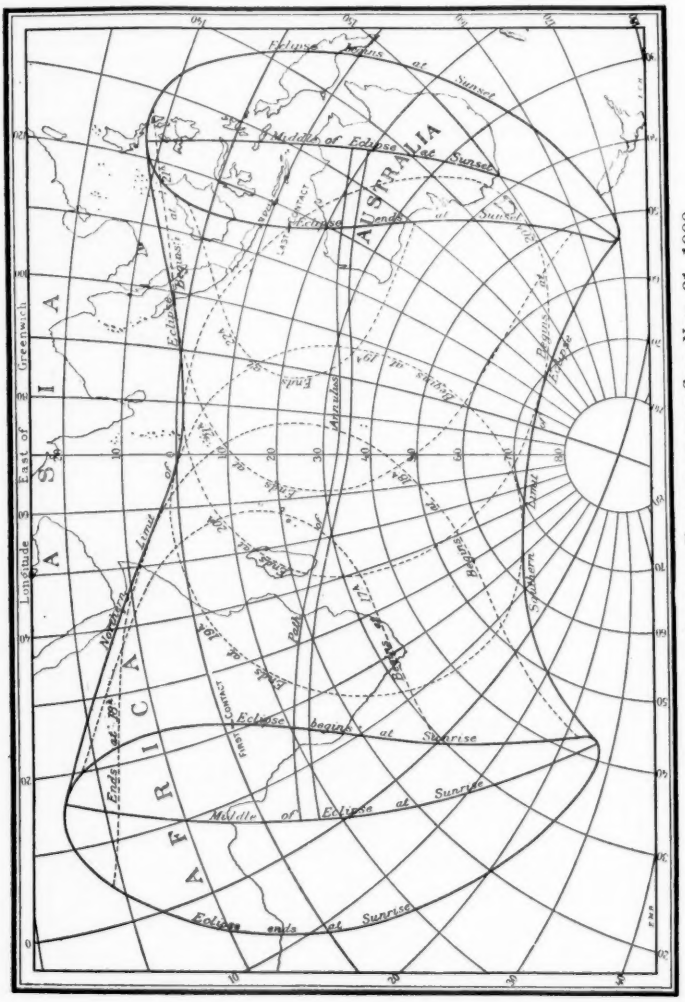


CHART OF THE ANNULAR ECLIPSE OF THE SUN, NOV. 21, 1900.

New Planetoid 1900 FL.—This was discovered by Dr. Wolf of Heidelberg, Germany, upon a plate exposed Sept. 26 for the purpose of finding the planet (406) [1895 *CB*]. It is of the 14th magnitude and its position was: Sept. 26.53 R. A. $22^h\ 46^m.8$; Decl. $-2°\ 36'$. Its daily motion is $-0^s.6$ and $-6'$.

VARIABLE STARS.

J. A. PARKHURST.

Minima of the Variable Stars of the Algol Type.

(Given to the nearest hour in Greenwich Time).

1900.

U CEPHEI.

	d	h
Dec.	2	10
	4	22
	7	10
	9	21
	12	9
	14	21
	17	9
	19	21
	22	9
	24	20
	27	8
	29	20
	32	8

S. CANCRI.

	d	h
Dec.	6	7
	15	19
	25	6

ALGOL.

	d	h
Dec.	2	22
	5	19
	8	16
	11	13
	14	9
	17	6
	23	0
	25	21
	28	17
	31	14

B. D. $+45^{\circ}3062$

	d	h
Dec.	4	16
	9	5
	13	9
	18	23
	22	19
	27	12
	32	2

δ LIBRÆ.

	d	h
Dec.	1	23
	8	23
	15	22
	22	22
	29	21

U CORONÆ.

	d	h
Dec.	2	15
	12	23
	19	21
	26	18

Y CYGNI.

$2P = 2^{d}\ 23^{h}.9$

Odd min.

Nov.	27	15
Dec.	27	14

R. CANIS MAJ.

$P = 1^{d}\ 3^{h}.3$

	d	h
Dec.	0	16

W DELPHINI.

	d	h
Dec.	3	9
	17	19
	22	14
	27	9

λ TAURI.

	d	h
Dec.	2	0
	5	23
	9	22
	13	21
	17	19
	21	18
	25	17
	29	16

NOTES TO THE EPHEMERIS.

The times for Y Cygni are taken from Duner's paper in No. 3633 of the *Nachrichten*; for the rest of the list from Hartwig's ephemeris in the *Vierteljahrsschrift*.

No ephemeris of Long Period Variables for 1901 is yet at hand.

MISCELLANEOUS NOTES.

PERIODS OF TWO VARIABLES DISCOVERED AT MOSCOW.—M. Blajko, of the Moscow Observatory, has published two papers in No. 3665 of the *Nachrichten* on two variable stars discovered by Madam Ceraski on Blajko's photographs. The conclusions ars as follows:

Variable in Auriga, $5^{h}\ 20^{m}.1$, $+ 36^{\circ}\ 49'$ (1900).

From photographs from 1895 to 1899 and visual observations in 1898, 1899 and 1900, M. Blajko deduces a period of 0.75 of a year, with observed maxima as follows:

(1). March or April.....1895
(2). December.....1895
(3). December 24.....1898
(4). September.....1899

The star seemed to be at maximum at the time of writing, June 21, 1900, therefore the following maximum is due in March, 1901. See Nos. 3529, 3553 of the *Nachrichten;* No. 457 of the *Astronomical Journal;* the *Astrophysical Journal*

for July, 1900, page 54 (here called (1922)); POPULAR ASTRONOMY for January, 1899, page 43, Feb. 1899, page 94, October, 1900, page 461.

Variable in Cepheus, $21^h\ 3^m.6 + 82°\ 40'$ (1900).

From photographs taken in 1896, 1897, 1898 and 1899, and visual observations in 1898 and 1899, M. Blajko deduces a period of about 1.4 years, with a maximum in 1899 September or early in October. See No. 3512 of the *Nachrichten*, Nos. 457, 475 and 482 of the *Astronomical Journal;* POPULAR ASTRONOMY VI, 532, VII, 493 and VIII, 461; *Astrophysical Journal* XII, 54 [here called (7579)].

It may be remarked in addition to M. Blajko's results that this variable perhaps enjoys the distinction of being the faintest ever observed, at the minimum of last summer the photographic magnitude was not brighter than the 18th.

ASTEROID NOTES.

Ephemeris of Planetoid (212) Medea.—This planet was observed in 1880, 1882, 1883, 1885, 1886 and 1888 and was photographed in 1894, but the data of the photographs are too inexact to permit of their use in determining the orbit. No later observations are known. Mr. B. Kudrjavzeff gives in *Astr. Nach.* No. 3643, the following approximate ephemeris for the opposition which occurs during this month:

1900	R. A.			Decl.		log Δ	Aberration.	
	h	m	s	°	′		m	s
Nov. 13	3	53	39	+ 26	54.91	0.2487	14	43
14		52	45		52.40	82		42
15		51	50		49.81	78		41
16		50	56		47.14	74		40
17		50	02		44.39	71		39
18		49	08		41.56	69		39
19		48	14		38.64	67		39
20		47	20		35.64	66		39
21		46	26		32.55	65		39
22		45	32		29.38	66		39
23		44	39		26.12	67		39
24		43	45		22.78	69		39
25		42	51		19.36	71		40
26		41	58		15.86	74		40
27		41	05		12.27	78		41
28		40	11		08.60	83		42
29	3	39	18	+ 26	04.84	0.2488	14	43

Elements and Ephemeris of Planetoid (295) Theresia.—Dr. Berberich in *Astr. Nach.* No. 3668 gives new elements of this asteroid, based upon observations made at five oppositions since 1890. These elements represent the observations very closely indeed.

Epoch Decl. 10.0, 1900

$$\left.\begin{array}{rl} M = & 8\ 35\ 38''.2 \\ \omega = & 143\ 50\ 29.2 \\ \Omega = & 277\ 24\ 13.4 \\ i = & 2\ 40\ 22.2 \end{array}\right\} 1900.0$$

$$\phi = 9\ 41\ 31.5$$

$$\mu = 758''.6107$$

$$\log a = 0.4466584$$

Berlin Midnight.	R. A.	Decl.	log r	log Δ
1900	h m s	° ′		
Nov. 10	4 59 38	+ 25 05.9	0.3655	0.1469
12	58 18	25 03.6		
14	56 52	25 00.7	0.3656	0.1403
16	55 21	24 57.2		
18	53 44	53.4	0.3657	0.1350
20	52 03	49.2		
22	50 18	44.4	0.3659	0.1310
24	48 29	39.3		
26	46 38	33.9	0.3661	0.1284
28	44 45	28.2		
30	42 50	22.3	0.3663	0.1271
Dec. 2	40 54	16.1		
4	38 58	09.8	0.3665	0.1273
6	37 03	24 03.3		
8	35 09	23 56.6	0.3667	0.1288
10	33 17	49.9		
12	31 28	43.1	0.3670	0.1317
14	29 42	36.3		
16	28 01	29.5	0.3673	0.1359
18	26 24	22.7		
20	4 24 51	23 15.9	0.3677	0.1414

Elements of the Planetoid (457) Pariana.—In *Astr. Nach.* No. 3667 Professor G. Boccardi gives the following elements of this asteroid, based upon the observations made in 1892, 1894, 1898 and 1899:

Epoch and Osculation, Oct. 31.51900, Berlin M. T.

$$\left.\begin{aligned} M &= 226^\circ\ 16'\ 42''.77 \\ \omega &= 83\ 25\ 28\ .53 \\ \Omega &= 85\ 56\ 17\ .34 \\ i &= 11\ 42\ 01\ .37 \\ \phi &= 9\ 34\ 30\ .57 \end{aligned}\right\} 1900.0$$

$$\mu = 840''.53887$$

$$\log a = 0.4169658$$

The opposition for this year occurred Oct. 19. The following portion of the ephemeris by Professor Boccardi, though late, may yet be of some use:

Berlin Midnight.	R. A.	Decl.	log Δ.	Aberration.
	h m s	° ′ ″		m s
Nov. 16	1 15 03.39	− 7 10 12.6	0.32515	17 34
17	14 29.58	7 08 10.3		
18	13 57.03	7 05 57.0		
19	13 25.77	7 03 33.0		
20	12 55.83	7 00 57.3	0.33186	17 51
21	12 27.22	6 58 11.1		
22	11 59.96	6 55 14.3		
23	11 34.07	6 52 06.8		
24	1 11 09.57	− 6 48 49.0	0.33908	18 09

GENERAL NOTES.

Change of printing offices and the procuring of an entirely new typographical dress for this publication are the main reasons for being late this month. Some of the supplies which were ordered from distant type founders have not yet reached us. We hope the December number will be ready for mailing nearly on time.

The Bulletin of Astronomy (French) for September has two full page plates, showing results in attempts to photograph Jupiter, Saturn, planetary nebulæ in Andromeda and Draco, and the nebula of Orion.

Full Sets of the Monthly Notices and the Memoirs of the Royal Astronomical Society. We learn with interest, that Ambrose Swasey, of the firm of Warner & Swasey, Cleveland, Ohio, has recently secured full sets of the *Monthly Notices* and the *Memoirs of the Royal Astronomical Society* which he found last year while in London. They are of course valuable, because complete sets are now scarce, and because they contain not only a history of astronomy, but also much about astronomical instruments that have been devised and used since 1820, (the year when the Royal Astronomical Society was founded); they are therefore largely useful to astronomers and instrument-makers as well.

New Allegheny Observatory. October 20 was the time set for the ceremonies attending the laying of the corner stone of the new Allegheny Observatory at Riverside Park, Allegheny, Pa. It was planned that the ceremonies should be brief and of the simplest character. Later some account of them will be given in this publication.

The November Leonid Meteors.—Although observers were generally disappointed last November on account of the small shower witnessed at the usual time of the Leonid display, they are preparing for a careful watch for this year. The mornings of the 14th, 15th and 16th of this month are the times thought of as most probable for seeing the best display. Astronomers are not well enough acquainted with this meteor stream or streams to predict very positively about the return of its densest parts in the long period of 33 years. It was confidently expected in November 1899, because brilliant showers of the Leonids had been seen in 1833 and in 1866. It is possible that this month will give a rich shower from this stream. Certainly no observer of meteors will let the opportunity pass without a faithful watch on the mornings above mentioned. Probably the morning of the 15th is as promising as any. The same drawback will hinder this year as last, viz.: the light of the Moon near the radiant in Leo.

Publication No. 1 Vassar College Observatory.—The first of the publications of Vassar College Observatory has been received. It is a catalogue of stars within one degree of the North Pole, and a study of the optical distortion of the Helsingfors astro-photographic telescope deduced from photographic measures. This work was done by Caroline E. Furness, assistant in the Observatory of which Mary W. Whitney is director.

This interesting paper was submitted by Miss Furness in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Faculty of Pure Science at Columbia College, New York City.

The Vassar College Observatory was established when the college was first opened in 1865, its purpose being for instruction rather than for scientific work for publication. Its first director, Maria Mitchell, became widely known, as a discoverer of comets, and she was honored by being the recipient of a medal from the king of Denmark for the discovery of a comet in 1847. "Professor Mitchell published a series of observations on the surface features of Jupiter and Saturn in *Silliman's Journal* and the *American Journal of Science*." Since 1890 more

observational work outside of instruction has been attempted, attention being given mainly to comets and the minor planets.

The position of this Observatory is:

Latitude.....41° 41′ 18″
Longitude..... 4^h 55^m 53^s.6

west of Greenwich, which was determined by Professor Mitchell in 1872. The longitude was determined by aid of telegraphic signals in connection with Harvard College Observatory in 1877.

The Observatory is provided with a 12-inch equatorial the object-glass of which was made by Fitz of New York, but recently recut by Alvan Clark of Cambridgeport, Mass. The re-mounting of the telescope was done by Warner & Swasey, of Cleveland, Ohio, in 1888.

The Repsold measuring machine by which the work of the paper above referred to was done, was the joint gift to the Observatory, of Miss Catherine Bruce and Mr. Frederick Thompson.

We hope soon to have an illustrated paper setting out fully the method of work used by Miss Furness in obtaining the results to which reference has been made.

Eros at Yerkes Observatory with 40-Inch Equatorial.

Oct.	2	Evening, Midnight and Morning.
	3	... Midnight ... ...
	4	... Midnight ... ...
	8	Evening, Midnight and Morning.
	9	Evening, ... Morning.
	10	... Midnight ... ...
	11	Evening, Midnight and Morning.
	14	Evening, ... Morning.
	15	Evening, ...
	16	Evening, Midnight and Morning.
	17	Evening, Midnight and Morning.
	18	... ... Morning.
	25	Evening, Midnight and Morning.
	26	Evening, Midnight and Morning.
	27	Evening, ...
	30	... ... Morning.
Nov.	1	Evening, ... Morning.
	2	Evening, Midnight and Morning.
	3	Evening, Midnight and Morning.
	4	Evening, Meridian and Morning.
	5	Evening, Meridian ... ...

In a few of these measures it has been necessary to use stars as small as 12½^m or 13^m. This could not be avoided if measures were made at all at such times.

Since Eros has become bright, it is seen to be of a slightly yellowish color.

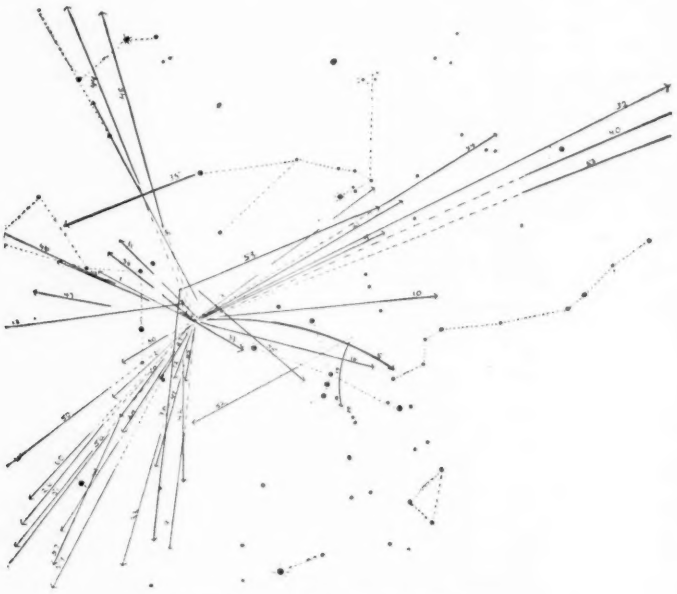
A power of 700 diameters is used when possible, failing this, 460.

Every available opportunity has been used to secure measures of Eros since October 1.

On every night that measures are made, the difference of declination of Atlas and Pleione if the Pleiades are measured, and frequent measures of the difference of declination of Electra and Celæno are also made, as a check on the changes taking place in the great telescope. Of Atlas and Pleione about 180 nights' measures have been made since the erection of the 40-inch. This will give a thorough check on any changes taking place in the great object-glass or tube and micrometer.

E. E. B.

The ν Urionids of 1900, Oct. 18, 1900 (12.50-4.50).—The night of Oct. 18, 1900 at 9:00 was cloudy, with rain. At 12:30, however, it was clear, except for slight cloud patches. At 12:45 the sky was clear. There was no



THE ν ORIONID SHOWER OF METEORS.

Moon until after 2:00. Together with the ν Orionids there were some shooting stars, a large part of which radiated from β Tauri, and a region between δ and η Orionis. Some meteors, Nos. 36, 42, 48, 68 (and 55) seemed to be from a separate radiant. No. 33 instead of shooting exactly from ν Orionis, started a little north of it. There were two Leonids, a good sign so far ahead of the time of the shower (Nov. 13). Any (ν Orionis) of this shower brighter than 2d magnitude had slight trails. No. 4 was a little brighter than 1st magnitude, blue and left a trail. No. 5 started as 2nd magnitude and suddenly burst into a (—3)rd magnitude, green meteor of striking brightness. No sound came. It also left a trail. No. 9 left a white trail. At 2:14-16 there were four faint shooting stars in Orion. One curved very much. Two came at the same time. Nos. 24, 26 left trails. No. 35 started from β Tauri and was very broad, of 0 magnitude. It was a broad streak. A large part of the meteors now were swift. Nos. 40, 48 and 49 left trails. Nos. 50 and 51 were very swift. At 4:50 observations stopped. The meteors were of medium speed, having trails brighter than 2nd magnitude. There were 17 shooting stars recorded not on map, 5 unrecorded, 2 Leonids, 37 ν Orionids and 6 uncertain; which amount to 68 in all.

The ν Orionids were of medium speed, usually leaving trails or streaks of a white or red color. They came one in every 5½ minutes. The shower was not a brilliant one, nor were there many meteors. They seemed to come in shoals, at

one time there was an interval of 23 minutes without one, and another interval of 15 minutes. When most were seen was between 2:50 and 3:35 when there were 15. There were a very large number of shooting stars. All that were recorded (not on map) were within the region of Orion, Gemini and Taurus.

ROBERT M. DOLE.

91 Glen Road, Jamaica Plain, Mass.

Observing Eros at Washburn Observatory.—Replying to your request of recent date: Observations of Eros in accordance with the plan proposed by the Paris Conference have been made by the undersigned with the 40cm. equatorial of the Washburn Observatory on every clear night since Sept. 29. On twenty-one nights the planet has been compared with two or more stars and on two nights, owing to unfavorable conditions, with one star only. In every case rectangular co-ordinates have been measured and especial care has been given to the determination of instrumental constants which can affect the observations.

UNIVERSITY OF WISCONSIN, Madison, Wis., GEO. C. COMSTOCK.
Nov. 6, 1900.

Perturbations of the Major Axis of Eros by the Action of Mars.—From an instructive article by H. N. Russell in the *Astronomical Journal* (No. 484) the following summary is taken:

(1). It has been shown by actual computation that Le Verrier's method of interpolation, which is theoretically capable of solving any case of general perturbations, will solve the case of Mars and Eros practically, that is, without a prohibitive amount of labor.

(2). It has been found that the "great inequality," of period about 1000 years, will not affect the place of Eros sensibly during the next dozen years, after which time it may be approximately determined.

(3). The perturbations of moderately long period are much the largest produced by Mars on any planet. They may displace Eros by 90″ in mean longitude; and since at a perihelion-opposition any change in the mean longitude of Eros produces one ten times as great in its geocentric longitude, the measurement of this displacement will eventually lead to a valuable determination of the mass of Mars.

Knowledge Diary and Scientific Handbook is intended to form an aid to the labors of scientific workers in all branches, notably in astronomy, and is issued in conjunction with *Knowledge*. It is designed to meet a well-marked want, now that the circles of students in every branch of scientific work are so extensive, and the need of an authoritative record so much felt.

Although the scope of the work is mainly astronomical, it is not intended to confine its usefulness entirely to that science, and the diary portion of the book is of course available for every description of record and observation work.

The new handbook will make its appearance with the beginning of the new century, and will contain a retrospect of the remarkable advances which Science has made in the course of the Nineteenth Century.

Other points of the contents will be twelve star maps showing the night sky for evey month of the year, with appropriate descriptive matter; a calendar of notable events; the hundred brightest stars and a monthly astronomical ephemeris. Under these and other important subdivisions of the work, will appear original essays to make the work generally useful.

Meeting of Astronomers at Buffalo.—A correspondent suggests the possibility of a convention of astronomers to be held in connection with the Pan-American Exposition which is to be in the city of Buffalo, N. Y., May 1 to Nov. 1, 1900. It is possible that such a meeting could be secured, if the matter were planned for soon. We would gladly receive suggestions from our readers who are interested in such a convention.

Professor W. H. Wilson at Wooster, Ohio.—Our readers will be interested to learn that Professor W. H. Wilson, who has been connected for some time with Geneva College, at Beaver Falls, Pa., has accepted the position of Professor of Mathematics in the University at Wooster, Ohio, and has already begun his work in the new position.

His duties include, for the present, Dr. S. J. Kirkwood's astronomical work as well as the mathematics during Dr. Kirkwood's illness.

PUBLISHER'S NOTICES.

Contributors are asked to prepare copy carefully, and write *all proper names very plainly*. If other language than the English is used to any considerable extent it should be type-written. Manuscript to be returned should be accompanied by postage for that purpose.

All Drawings for publication should be done in Indian ink, twice the size that the cut will be on the printed page. The lines, figures and letters should be made even, very smooth and uniformly black in every part of the copy, in order to secure the best reproductions possible by the modern quick processes of engraving now most generally used.

Proofs will generally be sent to authors living in the United States, if copy is furnished before the tenth of the month preceding that of publication. We greatly prefer that authors should read their own proofs, and we will faithfully see that all corrections are made in the final proofs.

Renewals.—Notices of expiration of subscription will hereafter be sent with the last number of this publication for which payment has been made. It is especially requested that subscribers fill out the blank notice sent them and promptly return it to the publisher, as this publication will not be continued beyond the time for which it has been ordered.

Messrs. Wm. Wesley & Son, 28 Essex Street, Strand, London, England, are our sole European agents.

Reprints of articles for authors, when desired, will be furnished in titled paper covers at small cost. Persons wanting reprints should always notify the publisher when the copy is sent or the proof returned. For they cannot be furnished later without incurring much greater expense.

Subscription Price to Popular Astronomy in the United States, Canada and Mexico is $2.50 per volume of 10 consecutive numbers. Price per volume of 10 numbers to foreign subscribers $3.00.

All correspondence and all remittances should be sent to

WM. W. PAYNE,
Northfield, Minn., U. S. A.